Kinetics of the Degradation of Type 316 Stainless Steel by Liquid Lithium - Appendices

D.G. Bauer

June 1980

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FUSION TECHNOLOGY INSTITUTE

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Preparations and startup

In November of 1977 the argon-filled loop was heated to approximately 200 C. A preliminary distribution of controlled 120 volt electrical power was made to the trace heaters, mainly through dimmer switches. Most of the 50-odd heaters have to be powered in series or parallel with other heaters, as there are only 20 dimmer switch control circuits. Since these switches have a limit of 600 watts each, care has to be used in distributing the loads.

The trace heating was powerful enough to heat the loop as required. With the loop at about 200C most of the circuits could be wired to draw 1/4 or less of the 600 watt limit. Exceptions were the isothermal oven around the test zone, which required full power, and the radiator, which would require 208 volt power in order to heat it above the melting point of lithium (181 C).

One pipe, between the economizer and the radiator inlet, was accidentally heated to 740 C. This occurrence emphasized the need to carefully choose which of the 100 available thermocouples on the loop would be monitored on the 30 available channels of the strip chart recorders. An examination of the overheated pipe found it to be discolored to a blue-black but in good shape.

In November and December of 1977 a roughing pump with a liquid nitrogen cold trap was used to leak-test the lithium shipping tank, which leaked slightly. Since this tank has a welded bottom, it was assumed that the leak was in the flanged top lid or in one of the fittings on the lid.

A standard procedure was adopted for maintaining a pure atmosphere of argon over components holding molten lithium: argon over these components would be occasionally vacuumed out and the component backfilled with high purity argon at about 1 or 2 psi gauge pressure. This procedure, first used on the shipping tank, was later used for the dump tank and for the surge tank and freeze standpipe gas spaces.

A partial plug of lithium in the shipping tank Swagelok fitting prevented an initial attempt at installing a valved stainless steel dip tube into the tank until the lithium was melted. Even then the fitting had to be drilled out slightly oversize before the tube could be installed. This reduced the effectiveness of the otherwise good Swagelok seal. However, lithium would not touch this particular seal anyway.

A sample of "as-received" lithium was valved from the tank into an evacuated, preheated tube. From this point on, care was taken that each lithium valve would be hotter than 200C before an attempt was made to open or close the valve. Valve breakage might otherwise result.[1] Also, whenever heating any part of the loop, particularly through the melting temperature of lithium, care must be taken to prevent straining or rupturing the piping or vessels of the loop.

The lithium in the shipping tank was titanium hot-trapped[2] for five days at 600C and for one additional day at 650 C and was then cooled back to room temperature. The hot trapping took place under an argon atmosphere.

The lithium sample taken from the shipping tank was not analyzed until six months later, in June 1978, when the micro-Kjeldahl method was tried in order to determine the nitrogen content of the sample. The method was troublesome and imprecise; preliminary indications with a titration for ammonia were that the nitrogen content was 500 weight parts per million (ppm). The value might have been high due to nitride on the ends of the sample. Lithium exposed to air at room temperature nitrided visibly from a matte silver surface to a dull black in about 20 seconds. No steps were taken at this point to prevent atmospheric reaction with the lithium, other than to work quickly and thus minimize the amount of nitride formed before the cut lithium sample was placed in the Kjeldahl apparatus.

A two-stage vacuum roughing pump with a liquid nitrogen cold trap (always used when vacuum pumping the loop) and a thermocouple pressure gauge were used to show that the loop could be pumped down to an absolute pressure of 0.035 torr (35 microns Hg) in half an hour. However, with the three level probes in place on the surge tank, the pressure only fell to about 0.15 torr (150 microns Hg) in half an hour. There appeared to be a slight leak through the probes' ceramic insulators or the Swagelok fittings attaching the probes to the surge tank.

The shipping and dump tanks and their interconnecting tubing were heated to about 230 C and approximately 0.024 m^3 of lithium was transferred from the shipping tank into the dump tank through the 15 and 7 micron stainless steel inline filters. The transfer was made by difference in positive gauge pressures between the tanks. The volume transferred filled the dump tank with 10.5 inches of lithium. A Mine Safety (MSA) induction type level probe was used to monitor the rising level of lithium in the dump tank.* Its use was simple; the operating manual effectively explains the operation. The gain was set at "460" and the readout gave a maximum signal when the probe's sensing element was halfway "submerged" in the lithium (although the probe, in the well of the dump tank, was not actually in contact with the lithium.) The probe was raised and lowered in the well by using an extension rod through the loop enclosure roof. The rod was marked at one inch intervals by holes drilled through

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* see pp. 247, 260 for illustrations of probe and piping.

it; these holes also allowed a cotter pin to be inserted for holding the level probe at a given depth until the lithium level rose past it, as indicated by the probe's output signal going through a maximum. The probe appears to be quite sensitive; its reported accuracy is 1/8 of an inch.The probe was turned off and left partway into the well for several months at about 290C. Its cable then needed replacement due to melted insulation. The probe still worked.

During the transfer of lithium from the shipping to dump tanks, another lithium sample was taken. This sample was analyzed for nitrogen at Oak Ridge National Laboratory in February of 1979. The nitrogen content of this titanium hot-trapped lithium was 422 weight parts per million.

The lithium now in the dump tank was zirconium hot-trapped for a week at 500 C.[3]

The argon-filled loop was electrically heated again. During the course of a week of trial and error refinements, the heating loads were distributed between the control circuits to achieve an acceptable arrangement with most of the dimmer switches delivering about 1/4 of their maximum 600 watts (i.e., half-voltage, 60V) and with loop temperatures ranging from about 190 C in the lower part of the radiator up to 320 C in the upper radiator and upper part of the test zone isothermal oven. The "isothermal" oven was by no means isothermal at this time, with the lower part about 100 degrees C cooler than the upper part.

Although the main heater consists of six clamshell halves, during preheating some of the 208 volt circuits were needed to preheat the radiator and other parts of the loop. Only the two middle clamshell halves were used to preheat the main heater. There are no thermocouples along the length of the main heater but temperature readings from thermocouples at the ends of the heater indicated that the two middle clamshells were powerful enough for preheating.

Even with natural convection in the radiator retarded by a damper in the upper duct, heat losses from the radiator and its housing were about 5 kilowatts. It appeared that a large amount of forced airflow might not be needed in the radiator during the operating phase of the experiment.

During preheating extra insulation was added in several places including the pump cell, which was also wrapped with a heating tape. The cell is well heat-sinked to the pump electrodes and magnet poles.

At this preheating time also, several thermocouples connected reverse-polarity or inadequately insulated or spliced were repaired.

After the loop was heated, the spring-tensioned support hangers were tightened by hand so that each hanger was neither loose (not supporting any weight) nor so tight as not to yield under a firm up or downward force.

The stainless coupons were scribed for identification and were cleaned, weighed and assembled into the stringers. The number one stringer jammed in the hot test section during installation and had to be forcibly pulled out. The stringer had broken, apparently when the wire ties binded against the inside of the close-fitting test section pipe. After being blessed with the recovery of all the parts except for the tiny wire ties, which remained in the test section pipe,this stringer and the other three stringers were modified with deeper grooves for the wire ties and a stronger welded stop at the bottom of the stringer. After this, the stringers were easier to install and take out of the test sections.

In August 1978 the preheated loop was evacuated with a cold-trapped two stage roughing pump through the surge tank; in 10 minutes the pressure measured at the tank dropped to about 0.4 torr (400 microns Hg). With the freeze standpipes and valves also under the vacuum, about 0.9 torr (900 microns Hg) was the pressure reached after an additional 6 minutes. The loop was vacuumed for 2-1/2 more hours. The vacuum pump was valved off a few minutes prior to filling the loop with lithium. The pressure in the loop was not measured at this time; experience (above) indicated that it would have been less than 0.4 torr (400 microns Hg.)

With the loop evacuated and closed off from both vacuum and argon supply, the dump tank was partially evacuated using a liquid nitrogen cold trapped roughing pump. Adding a small amount of argon brought the tank pressure up to about 1 psia. The addition of argon in small amounts was controlled by filling the lower gas manifold, then valving of the argon supply and opening the manifold-to-dump tank gas valve to allow the small amount of argon in the manifold to enter the tank. The absolute pressure in the tank was kept below about 1.5 psia during the filling of the loop so that lithium could not rise higher than about 1.8 m into the evacuated loop. This was a precaution against overfilling the loop.[4]

The dump tank initially was filled to a level of 10.5 inches. The amount of lithium being added to the loop was gauged in terms of equivalent level of lithium in the dump tank; the level was monitored with the induction probe. Each additional inch of lithium transferred was noted. The progress of the lithium in the loop was indicated by temperature changes measured with thermocouples. The three or four thermocouples monitored were selected from those in the suspected vicinity of the front of advancing lithium. New thermocouples were selected as the filling progressed past those being monitored. The rising height of the lithium in the loop agreed substantially with predictions which had previously been made from comparisons of the relative volumes of loop components and the volume of the dump tank.[5] (See Appendix G).

When about 3.5" of lithium had been transferred from the dump tank, the lithium had risen nearly to the surge tank. The tank was then vacuumed for 4 minutes. The vacuum was again valved off and 2" more lithium was added from the dump tank. (A total of 5.5" transferred so far.) Two inches of lithium were now in the surge tank, and the lower short-out probe was actuated. The continuous level probe was also indicating contact with lithium. The evacuated space remaining in the economizer and radiator was by now sealed off by lithium.

During the filling only one of the two drain/fill valves from the dump tank to the loop was opened at any one time, although both were alternated to keep the level approximately equal in the "lower" or "left" part of the loop (test sections, heater, pump) and the "upper" or "right" part of the loop (radiator, right end piping). A temperature change was not seen in the high right pipe between the economizer and the top of the radiator, possibly because up to now any lithium coming up toward this section would also be rising in the parallel pipe[4] from the lower radiator to the economizer, and flowing down in the outer pipe of the economizer. The difference in heights of the two points might prevent the immediate filling of the upper end of the economizer.

With some 5.5" of lithium transferred into the loop, filling was halted and the dump tank supply of lithium was replenished by transferring an additional 5" of filtered lithium from the shipping tank. During this transfer, trace heating tapes on the tubing between the two tanks were burned out by overheating. At this time or before, there was apparently a slight film leakage of lithium from the two filters.

After a lapse of two hours, and with the larger reserve of lithium now in the dump tank, filling of the loop resumed. When the lithium had risen some 8" into the surge tank, the second short-out level probe went on, enabling a calibration of the continuous level probe (from the continuous probe's output at the two levels where the short-out probes contacted the lithium).

Additional lithium was added through the fill/drain valve serving the radiator (thus reaching the surge tank through the economizer) until the surge tank was 11 inches full. A total of 9 inches of lithium, as measured at the dump tank, had been charged into the loop. This was about .02 m^3 or 8 kg of lithium.

The initially evacuated economizer should now be as full as possible, but a small volume of entrapped gas must remain in the upper part of the loop. To fill this void, it was decided to increase the pressure in the surge tank and standpipes. Too low a pressure here might allow the gas entrapped in the economizer to expand, pushing lithium out to overfill the surge tank or standpipes.

Too high a pressure could, if the void in the economizer were large enough, force all the lithium from the surge tank into the economizer, along with argon bubbles which would then be difficult to remove from the economizer. Therefore, the pressure adjustment was made with care, as follows:

The top-of-loop gas manifold (serving the surge tank and freeze standpipes) was evacuated. The vacuum pump was valved off and the valve between the gas manifold and the surge tank was very slowly cracked slightly open. Careful observation of the continuous indicator showed that no level change occurred in the surge tank. Then, each of the four ball valves between the evacuated adapter pipes and the freeze standpipes was carefully opened. Again there was no change in the mean level in the surge tank, although there was a slight oscillation in the level.

Argon pressure was very slowly increased in the surge tank and freeze standpipes. (The gas pressure above these components must be equal or lithium would overfill some of them.) Controlled amounts of argon at about 1/4 psig pressure were admitted into the 20 ft of 1/4" gas tubing from the argon supply cylinder and up to the top-of-loop gas manifold. The valve at the cylinder was then closed and the valve to the manifold was opened to allow a shot of argon to enter the upper part of the loop. The ratio of tubing volume to the volume of the top manifold and unfilled parts of the surge tank and freeze standpipes was such that each shot of argon into the loop through the initially evacuated surge tank increased the loop pressure by about 1 psi.

The continuous level indicator showed no change in the surge tank lithium level as the pressure was raised to a final value of about 1 psig. This indicated that the volume of gas entrapped in the economizer was small.

The freeze standpipe ball valves were closed and trace heating there was turned off. Thermocouples indicated that the freeze plugs formed.

The additional thermal conductance within the piping, due to the lithium now in the loop, smoothed the temperature distribution somewhat. The test zone still varied between 220 and 300 C from top to bottom. Extreme temperatures in the radiator were 200 C at the bottom and 320 C at the top.

Two days after filling the loop, trace heating of the pump cell was increased and an attempt was made to get the electromagnetic pump to circulate the lithium.[6] After 15 or 20 minutes of cautiously turning the pump on and off at about 50 volts (10% setting with current reading of 6 amperes) the loop temperatures as shown on the strip chart recorders began to converge, indicating that lithium was flowing. Before convergence of the temperatures, the only indication of possible flow was a slight temperature rise rise 5 cm downstream of the pump cell. (approximately 260 to 290 C). This temperature rise may have been due to ohmic heating of the pump cell. There was no flowmeter signal on the recorder; later it was learned that the printout wheel had not been synchronized with the selector switch and the wrong recorder channel had been monitored.

The pump was set at 4% (less than 50 volts, 4 amperes primary current) and the loop temperatures eventually ranged from 280 C to 300 C, except in the radiator where the temperatures on the non-insulated finned pipes were from 290 C to 320 C. The four flowmeters read an average of 0.3 millivolts, indicating an approximate flow rate of 10^{-4} m^3s^{-1} (0.05 kg s^{-1}).

Half of the 5 kilowatts devoted to the radiator heating was then shifted to the main heater. The loop came to a new steady state with an overall temperature difference of about 90 degrees C between the hot and cool zones. The hot-zone temperature was increased by steps to 420 C during a period of several weeks in which energy balances and mass balances were used to calibrate the permanent magnet flowmeters more accurately (see Appendix O). Finally, on September 20, 1978, the maximum temperature setpoint was increased to 449C, with the test section flowrates set in a roughly geometric progression to give lithium velocities between 0.4 and 1.4 m s^{-1}. Under these conditions the regular operation of the corrosion experiment began.

NOTES

[1] According to Mausteller (1967) valves may be the most troublesome component in a liquid metal system. It is standard practice to minimize the number of valves used in the main flow path. Bellows valves have much longer lives when they are used in off-stream pipes, such as fill lines, rather than in-stream for throttling the flow. Throttling valves can chatter and fail by fatigue. In the lithium loop four valves are used to control the velocity of lithium through the four test sections.

When adjusting a bellows-type valve, care must be taken that the valve temperature at the bellows is higher than the melting point of the alkali metal, or the bellows may very easily be broken in the attempt to turn the valve stem.

The bellows seals of liquid metal valves are very thin. The approximate thickness of the stainless foil in the bellows is .1 mm (.004"). The bellows are thus twenty times thinner than the average pipe wall in the loop.

The four flow control valves were preset after calibrating the flowmeters and thereafter not adjusted unless the meters were recalibrated. (No recalibration was attempted in the first 15 months of operation.) One valve, in the first test section (toward the "back" of the loop) would not close completely. This made the calibration of the three other valves slightly more difficult. This valve was then chosen as the one to control the highest-flow-rate test section.

At high temperatures valve seats may gall and self-weld. Perhaps occasionally working the flow control valves would forestall sticking, but in the U W loop this would risk changing the flow setting of the valve. Nupro flow control valves with long needles stuck immediately when closed in an ORNL experiment (DeVan, 1978PC). Judging from the flow behavior of the U W loop during the calibration of the meters, our valves are not the needle type; the valves must be turned almost all the way shut before flow begins to decrease. However,it was not hard to tune the valves to give the desired flows.

One of the dump valves has been opened and closed about five times on each of more than fifteen stringer servicings, with no noticeable degradation. This valve is kept at a temperature of 200-250 C whereas the flow control valves have so far been operated at 450 C to 500 C.

[2] The lithium was hot-trapped in December 1977, six months after it was received. Chemical reaction, or gettering (hot-trapping) of nitrogen from lithium is the most effective means of reducing the nitrogen content. Zirconium and titanium are good nitrogen getters and have been used by several investigators. Hot trapping is usually carried out at 700-800 C for one to several days (Cowles 1969; Draley and Weeks 1970; Mausteller 1967; ORNL notes).

With hot-trapping, the nitrogen content of lithium can be reduced to less than 10 weight ppm (ORNL notes, 1975).

The 17 kg of lithium was hot-trapped with 1.29 m^2 of 0.6 mm thick titanium foil supplied by Research Organic/Inorganic Chemicals (Heat HT K0241, Ti 50A, test T4693). This gave a 1/4 weight ratio of titanium to lithium. Gettering was done for five days at 600 C and for one additional day at 650 C.

[3] In June 1978 10 kg of the lithium (the contents of the dump tank, before any lithium had been charged into the loop) was hot trapped at 500 C for one week with approximately 1 kg of zirconium supplied by the same company which supplied the titanium. The zirconium was 0.25 mm thick, with a total area of 0.6 m^2. The effectiveness of the zirconium gettering is questionable, since some of the lithium eventually charged into the loop was not gettered with the zirconium, but was transferred into the dump tank (from the shipping tank) after the gettering. Also, the zirconium foil was accidentally exposed to air for several minutes at 320 C during a preheating of the dump tank.

The supplier's analysis of the titanium included 40 ppm N, 350 ppm O, 150 ppm C, and 130 ppm H. The zirconium analysis included 27 ppm N, 770 ppm O, 100 ppm C, and less than 5 ppm H. Both metals were "99.5%" grade.

[4] Pressure loading is generally recommended for being more manageable and less prone to experimental difficulties. Vacuum charging is the preferred method for the U W loop because the upper end of the economizer may entrap gases if pressure filling is used. Trapped gases would lower the efficiency of the economizer and might cause problems with the electromagnetic pump.

Mausteller (1967) recommends that parallel piping paths filled from the bottom of the loop should all be open and filling at the same time. The lithium will increase in volume by about 5% due to further heating after the fill; this should be taken into account to avoid overfilling and should be kept in mind during any subsequent heating of the loop.

[5] During filling, tempil sticks (a sort of heat resistant crayon which melts at a specified high temperature) can be helpful in following the liquid metal within the loop. A propane torch can be used to check where a pipe is filled if the insulation can be removed temporarily. An empty pipe will remain red hot for a few moments after being heated by a torch flame while a pipe containing lithium will conduct the heat away very rapidly.

Both of these methods seem inconvenient, somewhat messy, and in the case of the torch, a little dangerous.

[6] An electromagnetic pump will not operate properly until the cell wall has been wetted by the liquid metal. It may be necessary to heat the cell to help accomplish wetting.

If an electromagnetic pump is operated with its cell empty of liquid metal, the cell or the bus bars may overheat and melt. In the lithium loop, thermocouples have been spot-welded onto the cell. For safety it would be wise to add to the loop monitoring equipment a safety switch which would turn off the pump if the cell became too hot (ORNL notes, 1975).

During startup, the electromagnetic pump may be surged by applying power in pulses to break up gas bubbles in the loop. Such bubbles should find their way to the surge tank and out of the main flow path (although in the flow pattern of the U W loop they might enter the economizer and continue to circulate as well, or even simply lodge in the economizer and form a gas space.) During startup, the temperature distribution around the loop is a better indicator of flow than are the flowmeters, which may not yet be wetted by lithium and will therefore read incorrectly.

If the brazed joint between the pump cell and its nickel electrodes is in good shape, the pump should operate reliably. If efficiency falls unexpectedly, a deteriorating joint should be suspected. The pump cell is one of the thinner-walled sections of the loop. Some stresses have been introduced in the forming of the cell and in the brazing of the electrodes and shim silver. Three out of four loops used by Coyle(1958) failed at the pump cell before 1000 hours of operation. A pump cell severely cold-worked during forming failed in less than 50 hours on an Argonne National Laboratory lithium loop.(Lithium Users' Meetings, 1979).

The pump cell of the U W lithium loop was severely cold-worked during its forming. Subsequent vacuum-brazing of the nickel electrodes onto the cell apparently relieved the stresses. Operation to date has been satisfactory. The cell is a potential trouble point, nonetheless. Recently questions have arisen about the role that stress plays in corrosion of stainless steel by lithium. The effect is not yet well understood. (Lithium Users' Meetings, 1979).

In some cases (loops operating at higher temperatures, perhaps) air cooling of the pump is necessary. Such cooling has not been needed in the U W loop, possibly due to the low pumping power and the relatively low temperature of the system. If forced air cooling becomes necessary, the air might have to be ducted in order not to cool the rest of the loop unduly.

LOG OF RUNNING CONDITIONS

DATES	T_{max}	$\sim T_{min}$	PUMP	METERS' OUTPUT (approximate)				REMARKS
8/10-14/78	274C	290-320C	4%	about .4mv each				...........shakedown with no delta Temp
8/14-18	350	250	4%					
8/18-19	400		4%					
8/19-9/2	415	270-280	4%............................					Thermal and drain
9/2-9/9	370	250	4%					calibrations of
9/9-9/14	315	220	4%............................					flowmeters
9/14-9/19	315	250	4%					
9/19	390	230-260	8.2%	1.41	.70	.38	1.02	meters as per recorder
9/20-10/10	449	230-260	8.6%	1.40	.68	.36	.98	......first test period
10/14-10/17	449	230-260		1.37	.65	.31	1.00	......interim test period
10/19-11/8	449	250						second test period
11/18-12/11	449	250	9.4%	1.32	.64	.33	.99	......third test period
			8.4%	1.32	.65	.30	.97	(meters on 11/27 & 12/4)
12/18- 1/16	449	250	9%	1.38	.66	.32	1.01	......fourth test period
			9%	1.32	.61	.28	.95	(meters 12/22,1/5,1/10)
			9%	1.30	.60	.27	.92	
								Tmax=870 for 12 hours (1/1)
								Lithium sample N= 75 ppm(1/10)
1/18-3/8/79	449	250	9.6%	1.38	.64	.34	.99	fifth test period
			9.9%	1.35	.65	.35	.98	(meters on 1/20,2/3,3/1)
			10.2%	1.40	.66	.35	1.00	
								Tmax=850 for 10 hours(1/24)
								1/4"Lithium sample N=-?-ppm(2/8)
								Tmax=790 for 4-6 hours(2/9)
								1/2"Lithium sample N= 50 ppm(2/13)
3/10-3/21	449	250	10.0	1.35	.65	.37	1.00	sixth test period,#1&#2 new
								Tmax=870 for 8 hours (3/9)

LOG OF RUNNING CONDITIONS (CONTINUED)

DATES	T_{max}	$\sim T_{min}$	PUMP	METERS' OUTPUT				REMARKS
3/23-4/11	449C	250						seventh test period
4/12-5/1	449	250	10.1%	1.33	.67	.32	1.00	eighth test period
5/3-5/29	449	350	9.8%	1.33	.70	.43	1.01	ninth test period, lower ΔT
5/30-7/24	449	350	10%	1.32	.68	.43	1.02	tenth test period
				1.32	.66	.41	1.00	(meters at 6/4,7/2,7/7,7/23)
				1.31	.67	.41	.99	meters per potentiometer after 6/4*
				1.36	.68	.42	1.03	Lithium sample N=111ppm(7/13)
7/31-9/27	449	350	10%	1.36	.68	.42	1.03	eleventh test period
				1.36	.68	.42	1.02	(meters at 8/6,8/28,9/14,9/27)
				1.36	.68	.43	1.02	
				1.35	.69	.43	1.02	proportional Tmin control(9/25)
9/28-10/1	500	325	10%	1.60	.66	.40	1.04	shakedown without coupons
				1.57	.65	.40	1.00	(meters at 9/29,9/29,10/1)
				1.55	.64	.40	.98	
10/1-10/2	500	325	10%	1.31	.67	.43	.96	twelfth test period, new coupons
10/3-10/4	500	325	10%	1.32	.68	.43	.97	thirteenth test period
10/10-10/12	500	325	10%	1.36	.70	.45	1.00	fourteenth test period
				1.32	.68	.44	.96	(meters 10/10,11,12)
				1.31	.67	.43	.96	
10/19-10/24	500	325	10%	1.31	.67	.42	.96	fifteenth test period
				1.29	.65	.41	.94	(meters 10/19,20,22,23,24)
				1.28	.65	.41	.92	
				1.28	.65	.41	.92	
				1.25	.64	.41	.91	
10/27-10/29	500	325	10%	1.36	.72	.45	1.00	sixteenth test period
				1.24	.66	.40	.92	(meters at 10/27, 10/29)

* meter recorder offset; readings prior to 6/4 variable: about .2mv high?

LOG OF RUNNING CONDITIONS (CONTINUED)

DATES	T_{max}	$\sim T_{min}$	PUMP	METER'S OUTPUT				REMARKS
				1.33	.70	.44	.97	seventeenth test period
10/30-11/16	500C	325C	10%	1.32	.69	.44	.97	(meters on 10/31;11/3,7,.2,16)
				1.33	.69	.44	.97	
				1.44	.75	.48	1.05	lithium sample N= 69ppm(11/15)
				1.36	.71	.46	1.06(?)	gas bubble (11/16)
12/10--1/7	500	325	10%	1.44	.71	.38*	1.01	eighteenth test period
				1.33	.66	.39	.93	(meters on 12/10,11,14,19,21;1/3,7)
				1.26	.59	.35	.88	*#3 meter increased later on 12/10
				1.17	.56	.32	.82	Note apparently lower flows
				1.17	.56	.31	.81	
				1.16	.56	.32	.81	
				1.14	.55	.30	.79	
1/8-2/26/80	500	325	10%	1.23	.60	.34	.87	nineteenth test period
				1.20	.59	.26	.84	(meters on 1/8,9,15;2/1,8,26)
				1.19	.60	.32	.83	lithium sample N= 99ppm(1/15)*
				1.22	.61	.34	.85	lithium sample N= 64ppm(2/26)
				1.23	.61	.34	.86	
				1.18	.59	.33	.82	
2/28-3/19	500	325	10%	1.16	.57	.33	.82	twentieth test period
				1.14	.57	.33	.80	(meters on 2/28;3/12,19)
				1.17	.59	.34	.82	Recalibrate meters following pull 20
3/24-	500	325	12%	1.14	.60	.36	.84	twenty-first test period
				1.17	.61	.32	.85	(meters on 3/25,25(adj#3),4/19
				1.05	.56	.32	.77	(EM pump short ca. 4/7)
								lithium sample N= 79ppm(4/8)*

* No bypass flow in 1/15 sample. Very short bypass flow in 4/8 sample.

LOG OF DOWNTIME CONDITIONS

DATE	T_{max}	T_{min}	REMARKS
8/8-10/78			Loop just filled
8/18			Main heater overheat. Stop four hours
8/27			Scram. Stop 8 hours.
9/2			Scram. Stop 6 hours.
9/14			Drain tests.
9/28			Accidental freeze. Stop 22 hours.
9/29			2 Scrams, with pump continuing to run.
10/2			Scram.
10/9			Fuse blows. 12 hours off temperature.
10/10-13			#3,#4 first out/in.
10/17-18			#1,#2 first out/in.
11/8			#3,#4 second out.
11/9			#2 second out. Lithium in ball valve #1.
11/14			#1 second out.
11/15			All in.
11/16-17			
12/11-12			Remove Li_3N from ball valve #1.
12/13			#2,#3,#4 third out.
12/14			#1 third out.
12/15			All in.
12/16-17			
1/16/79			All fourth out.
1/17			#1, #2 in.
1/18			#3, #4 in.

LOG OF DOWNTIME CONDITIONS (CONTINUED)

DATES	T_{max}	T_{min}	REMARKS
3/8-9/79			All out/in fifth time.
3/21			All out sixth time. #3,#4 in.
3/22			#1,#2 in.
3/31			Fuse burns. Scram.
4/11-12			All out/in seventh time.
5/1-2			All out/in eighth time.
5/29-30			All out/in ninth time.
7/24			#2,#3,#4 out tenth time.
7/25			#1 out tenth time.
7/26-29			
7/30			All in.
7/31			Fix #4.
9/27			All out eleventh time. Last time for these coupons.
10/1			All in. All new coupons.
10/2-3			All out/in twelfth time.
10/4			#2,#3,#4 out thirteenth time.
10/5			Scram due to defective thermal recorder tube.
10/6-7			
10/8			#1 out thirteenth time.
10/9			#1,#2,#3 in.
10/10			#4 in.
10/12			All out fourteenth time.
10/13-14			
10/15			#2,#3,#4 in.
10/16-18			Down. Started keeping argon connected to thawed standpipes.
10/19			#1 in.
10/24-25			All out/in fifteenth time.

LOG OF DOWNTIME CONDITIONS (CONTINUED)

DATES	T_{max}	T_{min}	REMARKS
10/26/79			Down.
10/29-30			All out/in sixteenth time.
11/16			Gas bubble into economizer.
			#3,#4 out seventeenth time.
11/17-18			
11/19			#1,#2 out seventeenth time.
11/20			Coupons kept in 150°C oven overnight (instead of just 1-2 hours)
11/21-28			Down.
11/29			Fix #3.
11/29-12/9			Gas bubble service. Probe replacements. Test sections and electromagnetic pump section frozen twice each. Electromagnetic pump cell frozen 4 days.
12/10-1/7			All in.
1/7-1/8			#3, #1, #2 out eighteenth time. Fix #4. #4 out. All back in.
2/26			#2, #3, #1 out nineteenth time. Fix #4. #4 out.
2/28			#1, #3, #4 in. #2 sticks. File burr off end. #2 in.
3/19			#1, #2, #3 out twentieth time. Fix #4. #4 out.
3/20-24			Recalibrate electromagnetic meters and reset valves approximately.
3/24			All in.
ca. 4/7			Apparent short of EM pump but no shutdown or downtime.

APPENDIX B. LITHIUM LOOP COMPONENTS

System Photo and Drawing

Thermocouple, Heater, and Shim Stock Attachment

Electromagnetic Pump Piping

Meter Section Piping

Isothermal Zone and Freeze Standpipes

Surge Tank and Level Probes

Economizer

Dump System (Right End) Piping

Ventilation (Radiator) System

Tanks, Main Heater and Radiator

This section describes the loop in greater mechanical detail. It includes, for each component, particular descriptions and/or drawings showing thermocouples, hangers, insulation, and so on. It is important to know the location and orientation of such accessories in order to operate the loop, analyze data, troubleshoot, and repair the equipment.

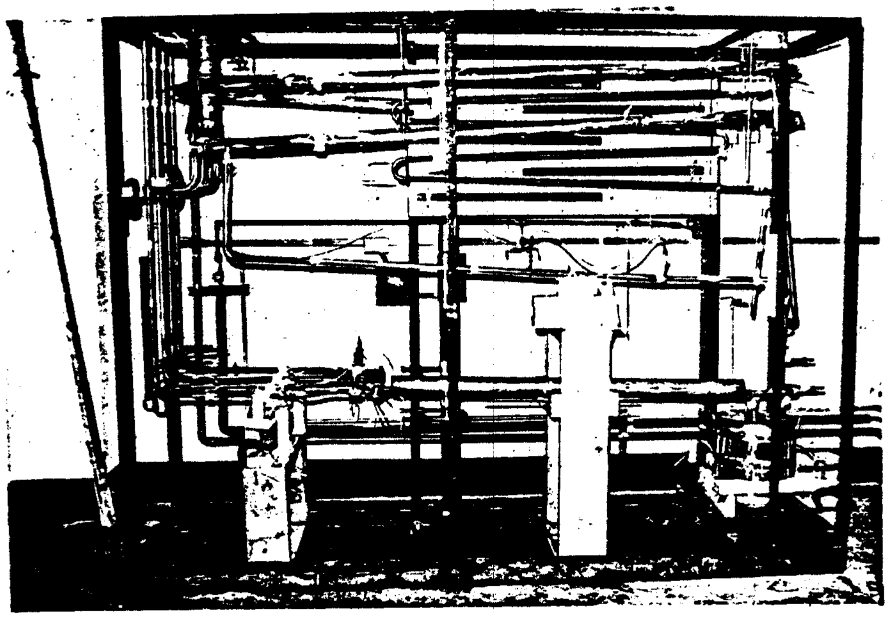
Heaters, thermocouples, wire-ties, and so on are described as in the preliminary report (July 1977) and in the lab notebooks. Notebook references are given in brackets, for Chemical Engineering Department notebooks 343,386,403,425,455,460,479 (books "1" to "7").

Insulation is pictured with sketches made in 1978 and 1979, with descriptions taken from the lab notebooks. Stainless steel wires are usually used to hold the insulation in place.

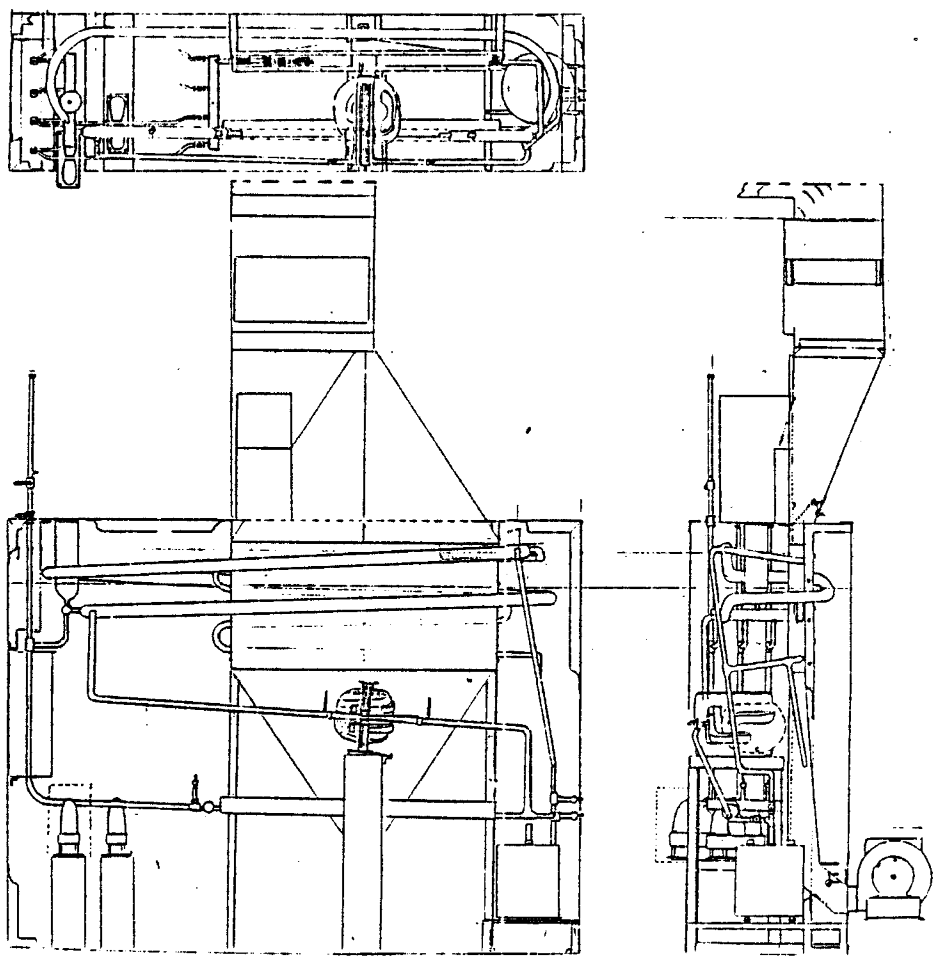
Kaowool, a diatomaceous silica insulation made by Babcock and Wilcox, has been used to insulate most of the loop. One-inch thick Kaowool blanketing is used in two layers on much of the piping, with the exception of the economizer, where the second layer is fiberglass. The fiberglass insulation, also used in outer layers elsewhere, is more resistant to crumbling; the inner glass fibers are quilted inside a fiberglass cloth. Kaowool can be used up to 1000C whereas mineral wool or glass insulation is good up to about 650C and is good enough for most parts of the loop.

Joints in the insulation were offset from layer to layer where this was possible. Shim stock (thin stainless steel sheet) under the insulation should keep the fibers from lodging under the tubular heaters, where their resistance to heat transfer from the heater to the piping might cause burnout of the tubular heaters.

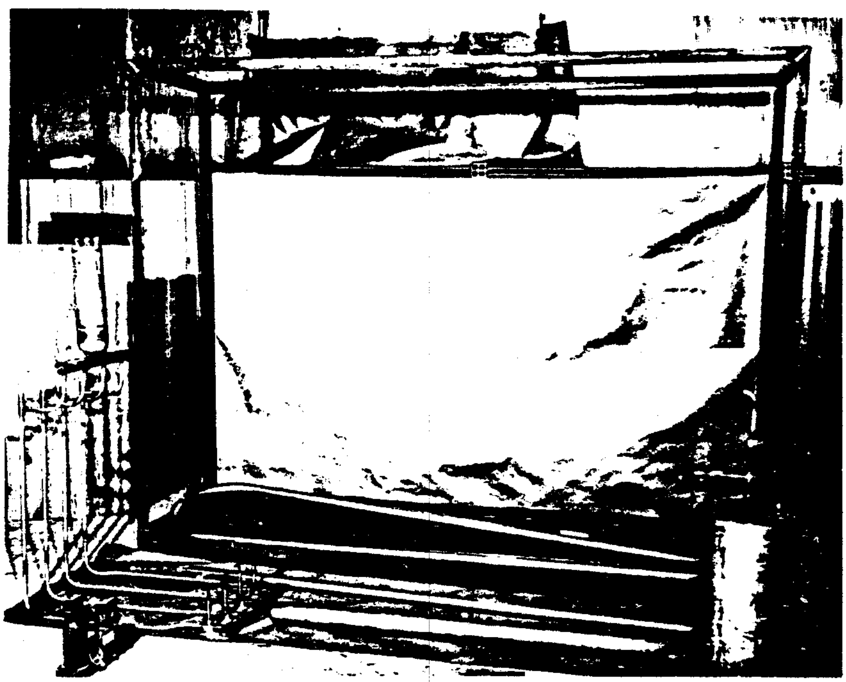
The tubular heaters are General Electric Calrods or Wiegand Company Chromalox heaters. The descriptions which follow give the heated length of these heaters. The overall length of the Calrods is about 9" longer than the heated length; the total length of a Chromalox heater is about 4-5" greater than the heated length. At least 2" of the terminal ends of the heaters should be bent outward through the insulation so that the terminal connections can be made in the cooler and more accessible space outside the insulation. These heaters should be bent according to the manufacturers' instructions, with special care not to break the fragile internal junction between the heating element and the terminal bolt (General Electric, Wiegand company catalogs).



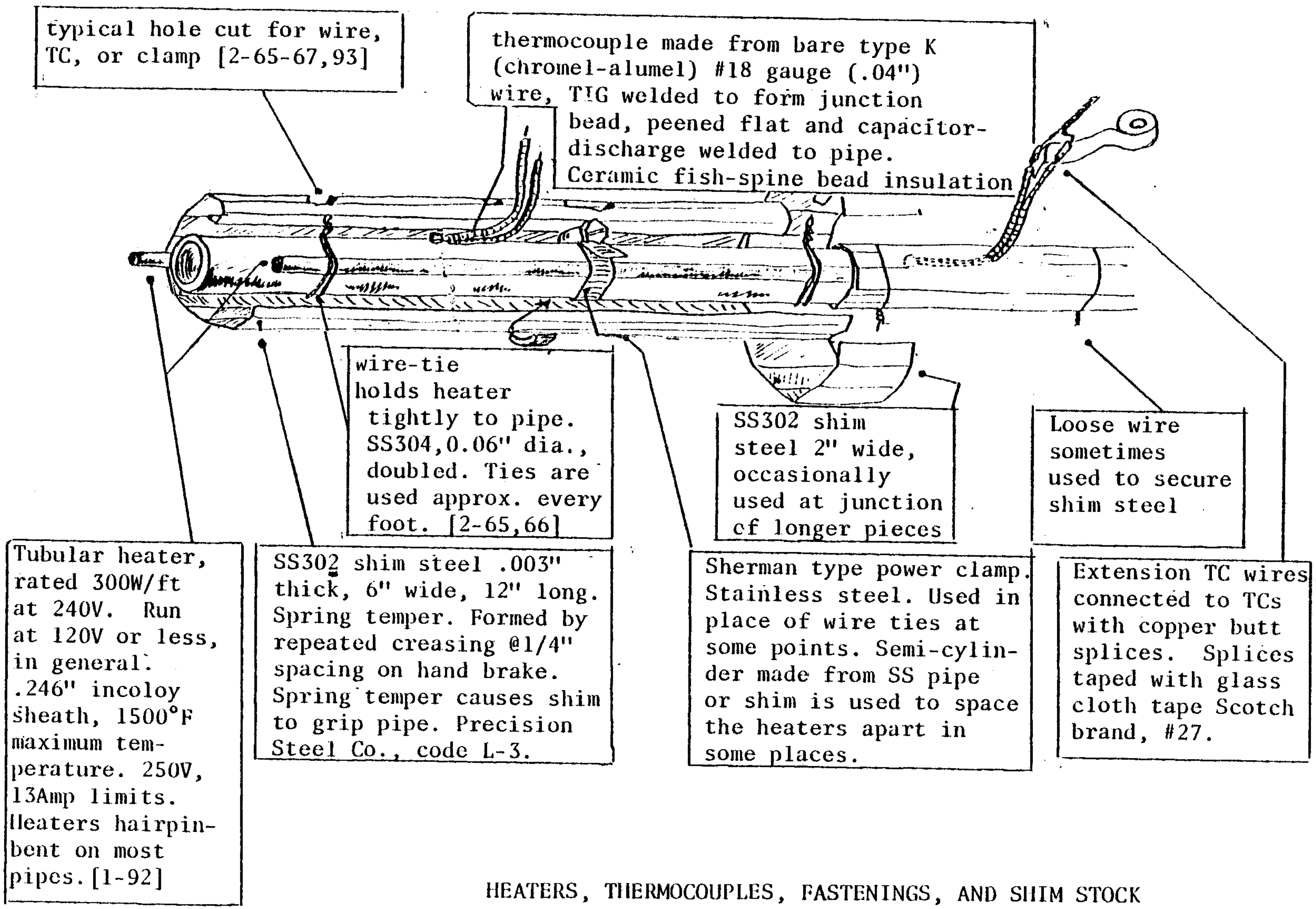
THE UW LITHIUM LOOP



LITHIUM LOOP ISOMETRIC DRAWING



LITHIUM LOOP COMPONENTS PRIOR TO ASSEMBLY



HEATERS, THERMOCOUPLES, FASTENINGS, AND SHIM STOCK

ELECTROMAGNETIC PUMP PIPING

Heaters, tubular, .246" incoloy sheath, 240V maximum [2-114]

#88	on	left vertical piping	77Ω,	190W,	31"*
#89		left horizontal piping	23Ω	625W	102"
#90		right piping	23Ω	625W	102"

Wire ties, with shim stock underneath, stainless steel [2-105]

on vertical sections, twists are to front
on horizontal sections, twists are to upper side

on left vertical piping, @[2", 10"]**
horizontal piping, [11",24",36",45",60",71",79"]
right vertical piping, [2",10",14"]

Thermocouples, 18 gauge chromel-alumel (type K) [2-105]

on left vertical piping, [6"]F<U***
horizontal piping, [17",42",45"] U<L
[52"] F+B<R
[57",64"] U<R
[77"] U<L
right vertical piping, [9"] R<U

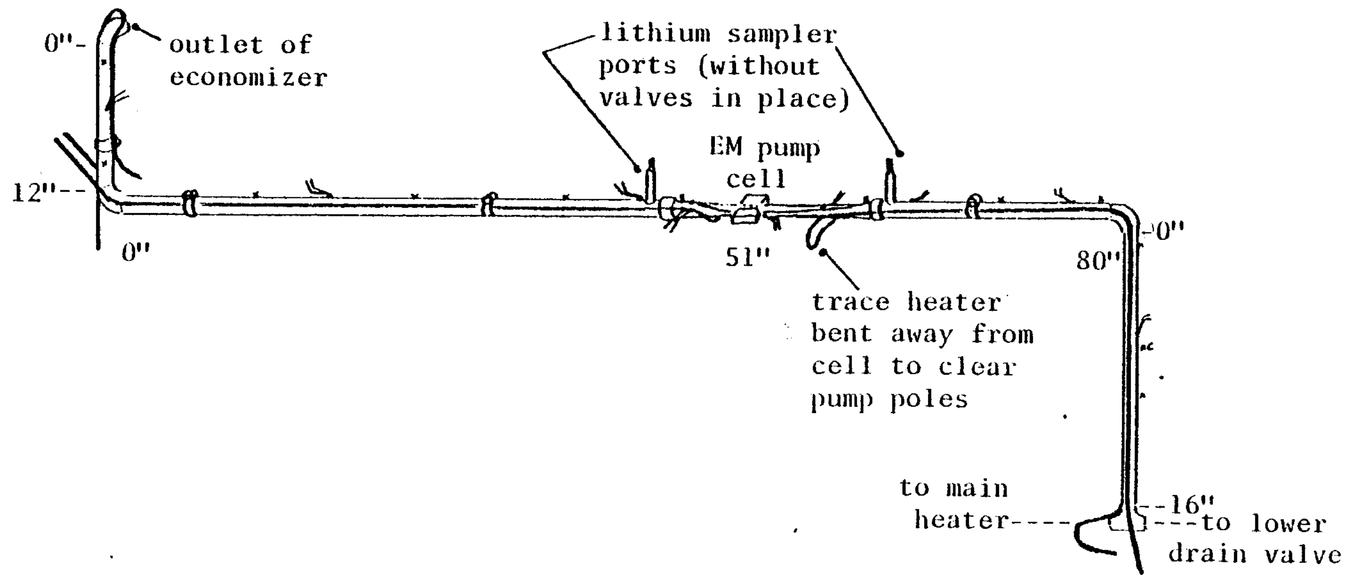
Clamps, power type, with spacer underneath, stainless steel [2-105]

on left vertical piping, [8"] R<F
horizontal piping, [6",30",69"] U<F
right vertical piping, [10"] R (wired);no clamp

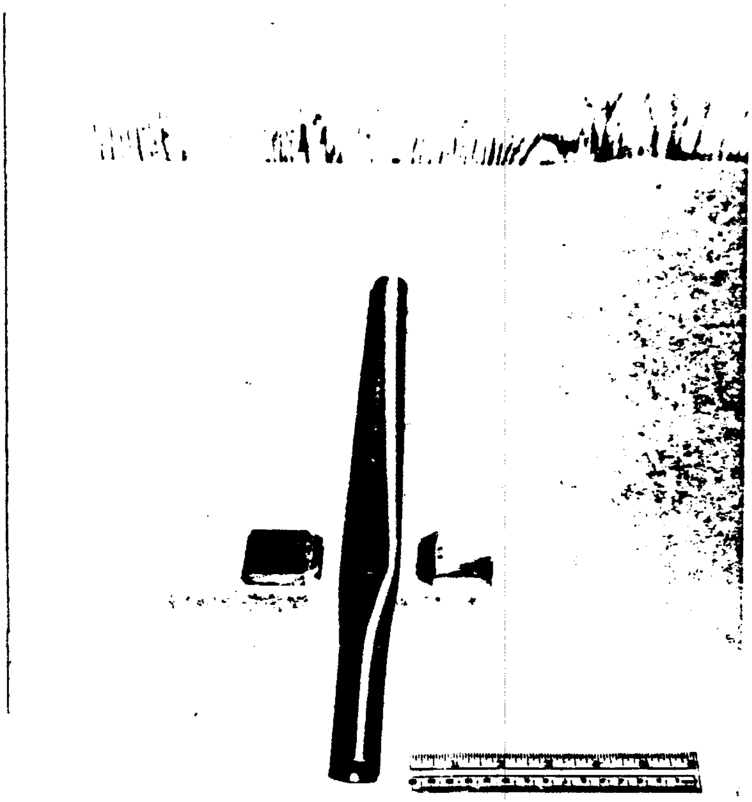
Fittings

on horizontal piping,	[43",62"]	Lithium sampler ports
	[44",61"]	Pump cell transitions
	[51"]	Pump cell electrodes

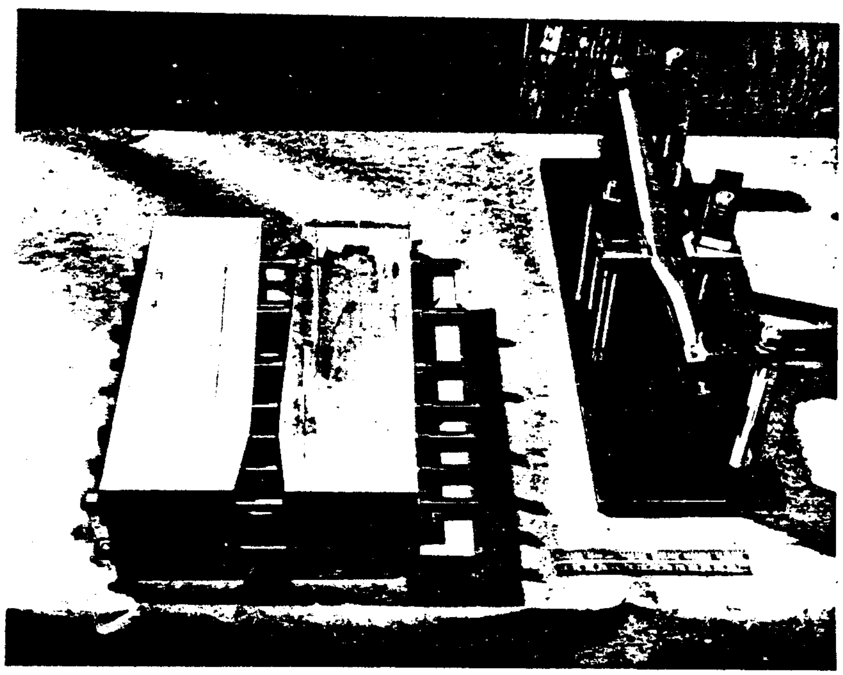
* Left vertical heater on left/right of pipe; terminals at bottom.
Horiz. & right heaters front/back of pipe; term: 89-left, 90 @ tee.
·· Heater approximate cold resistance, wattage @ 120V, heated length
** Left vertical piping 0" at top elbow, 12" at bottom elbow
Horizontal piping 0" at left elbow, 80" at right elbow
Right vertical piping 0" at top elbow, 16" at bottom tee
***Orientation on piping: U=up,D=down, L=left, R=right, F=front, B=back. Symbol< indicates direction in which thermocouple leads or screw head point, e.g., L<U is on left of pipe, points up.



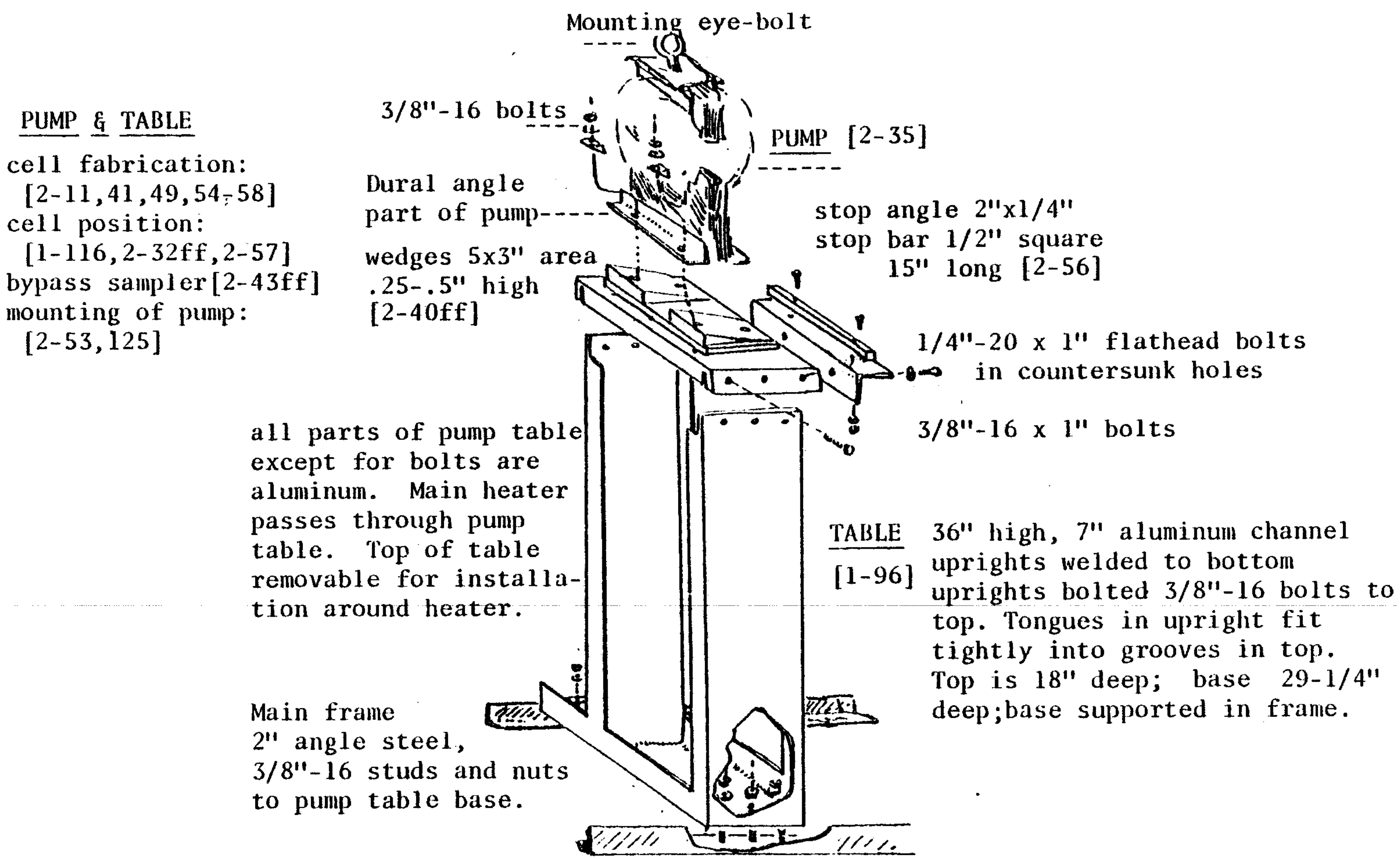
ELECTROMAGNETIC PUMP PIPING [2-105]



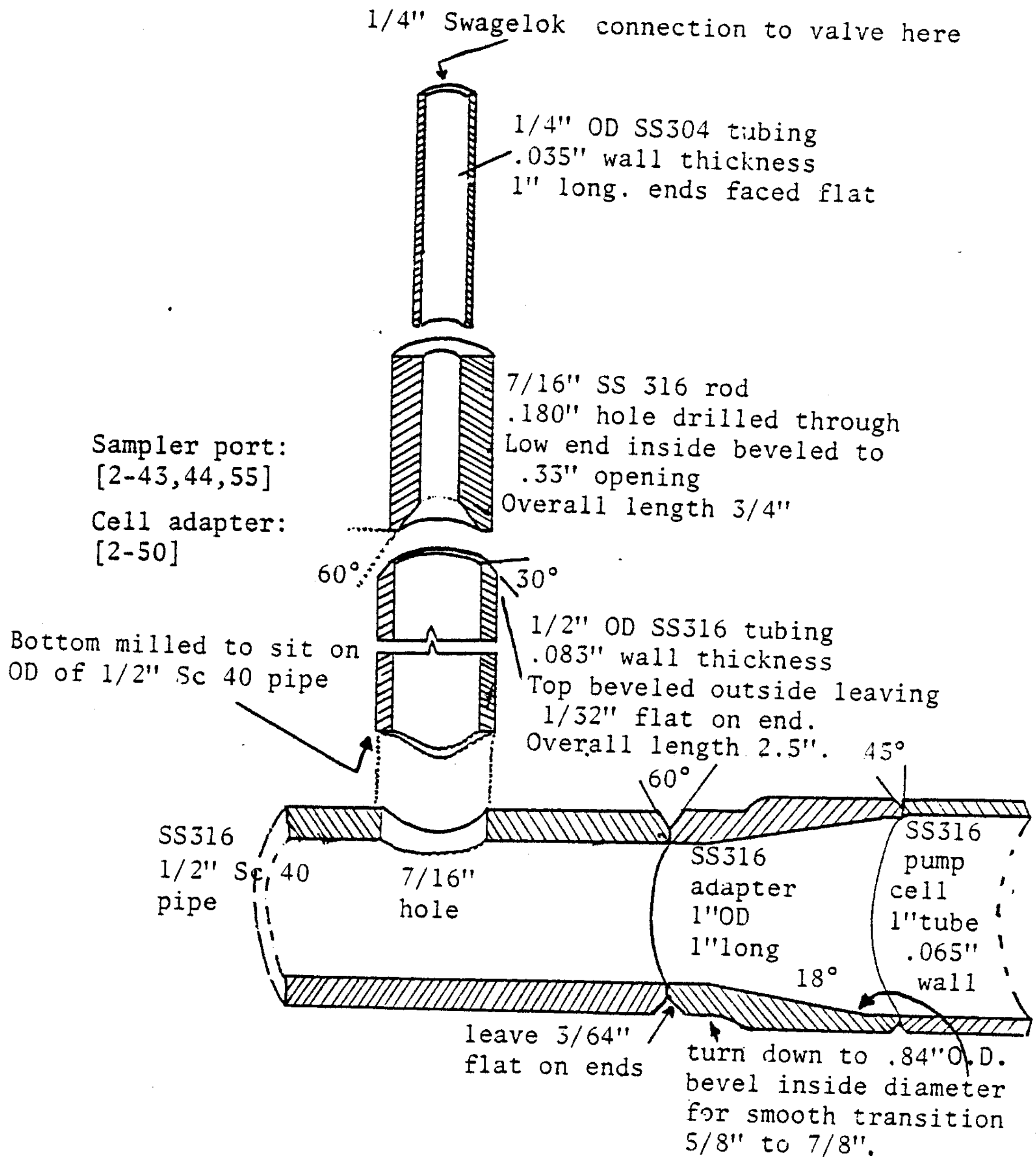
ELECTROMAGNETIC PUMP CELL PRIOR TO ASSEMBLY



ELECTROMAGNETIC PUMP CELL IN BRAZING JIG

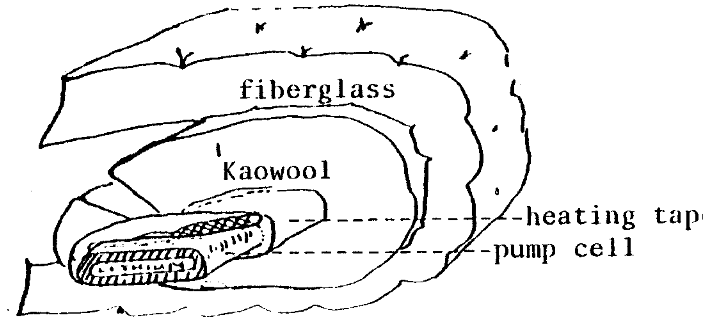


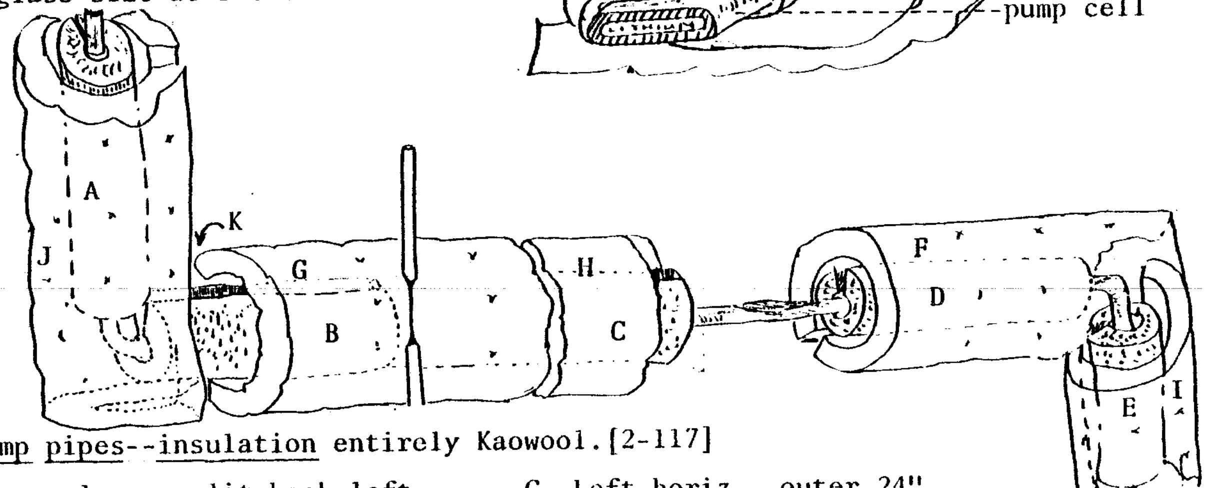
ELECTROMAGNETIC PUMP TABLE CONSTRUCTION



LITHIUM SAMPLER PORT & PUMP CELL TRANSITION

Pump cell insulation: [4-128]
Samox-insulated heating tape (rated for operation in direct contact with metal, at 800°C) 1"x48", 576 W, 120 Volts.
Heater tape is wrapped in contact with cell.
Layer of Kaowool with slit at back.
Outer layer fiberglass slit at back.





Electromagnetic pump pipes--insulation entirely Kaowool.[2-117]

A. Left vertical inner layer, slit back left.
B. Left horizontal, inner, slit up, 24" section.
C. Mid-left, horiz., inner, same as "B".
D. Right horiz., inner, slit up, several parts.
E. Right vert., inner, slit left, 24" section.
F. Right horiz., outer, slit down/back, 24".
G. Left horiz., outer, 24", slit down/back, split partly by hanger.
H. Mid-left, outer, slit down/back, 14".
I. Right vert., outer, slit back, 18".
J. Left vert., outer, slit right.
K. Between G & J. Slit back.

METER SECTION PIPING

Section 1 at rear of enclosure, section 4 at front.

<u>Heaters</u>, tubular, .246" incoloy sheath, 240V maximum,
on front/back of piping [2-114]

#21-#24 between meters & isothermal oven for sections 1-4,
terminals to left   58Ω, 250W, 41"*
#11/#13 between valves & meters for sections 1 and 3
terminals to right   77Ω, 190W, 31"
#12/#14 between valves & meters for sections 2 and 4
terminals to right   58Ω, 250W, 41"

<u>Wire ties</u>, with shim stock underneath, stainless steel [2-84,104]

on sections 2 and 4   [9",15",23"] U, [31"] left/outward**
on sections 1 and 3   [10",17",25"] U

Thermocouples, 18 gauge chromel-alumel (type K) [2-84,104]

on sections 2 and 4   [6",27"] U<R***
on sections 1 and 3   [12",29"] U<R

<u>Clamps</u>, power type, with screw head outward toward nearer wall of loop [2-84,104]

on sections 2 and 4   [2.5"]U   [19"]U
on sections 1 and 3   [14"]U   [31"]L

<u>Fittings</u> [2-84]

on sections 2 and 4   [22"]   Electromagnetic meter
on sections 1 and 3   [12"]   Electromagnetic meter
all sections,   [33"approx.] Isothermal oven

* Heater approximate cold resistance, watts at 120V, heated length
** Distances measured from first bend in test section (first bend is about 5" downstream from lower lithium manifold)
***Orientation on piping: U=up,D=down, L=left,R=right, F=front, B=back. Symbol < indicates direction in which thermocouple leads point; e.g., U<R means thermocouple on upper side of pipe with leads pointing to the right.

LOWER LITHIUM MANIFOLD

Heater, tubular, .246" incoloy sheath, 240V maximum, [2-104]
runs along each valve, along the manifold between valves, and front to back of manifold two times. See drawing. Terminal at back and terminal between valves 3 and 4.
#10 23Ω 625W 102"*

Wire ties, stainless steel [2-104]

on manifold, every 3", twists downward
on each manifold/valve connecting pipe, twists downward
on each valve tube twists sideways

Thermocouples, 18 gauge chromel-alumel (type K) [2-104]

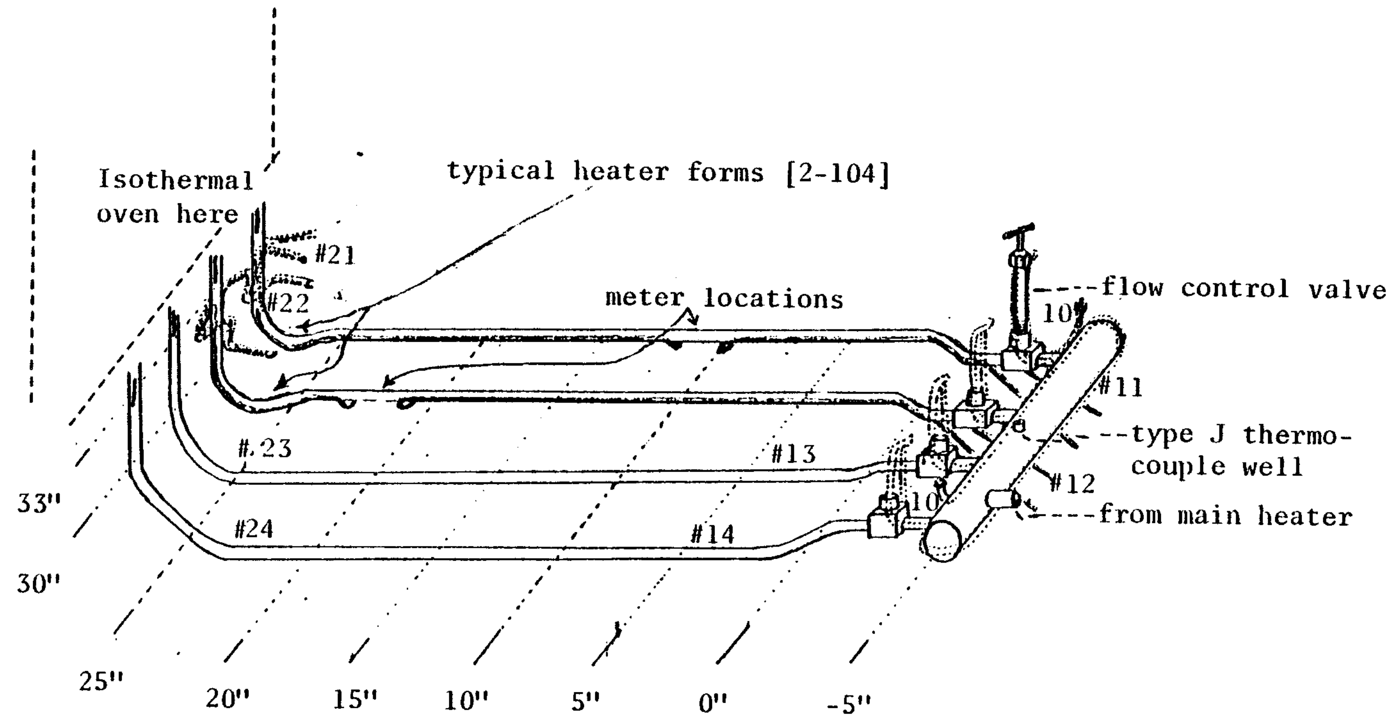
on manifold, front to back [3"] U<F, [9"] D<R, [15"]U+D<B ***
on each valve, under block, points down to right D<R
on each valve at top of tube, points up to front U<F

Thermocouple, control, iron-constantan (type J) [3-130]
in thermocouple well in center of manifold, extending down into manifold in lead/tin melt.

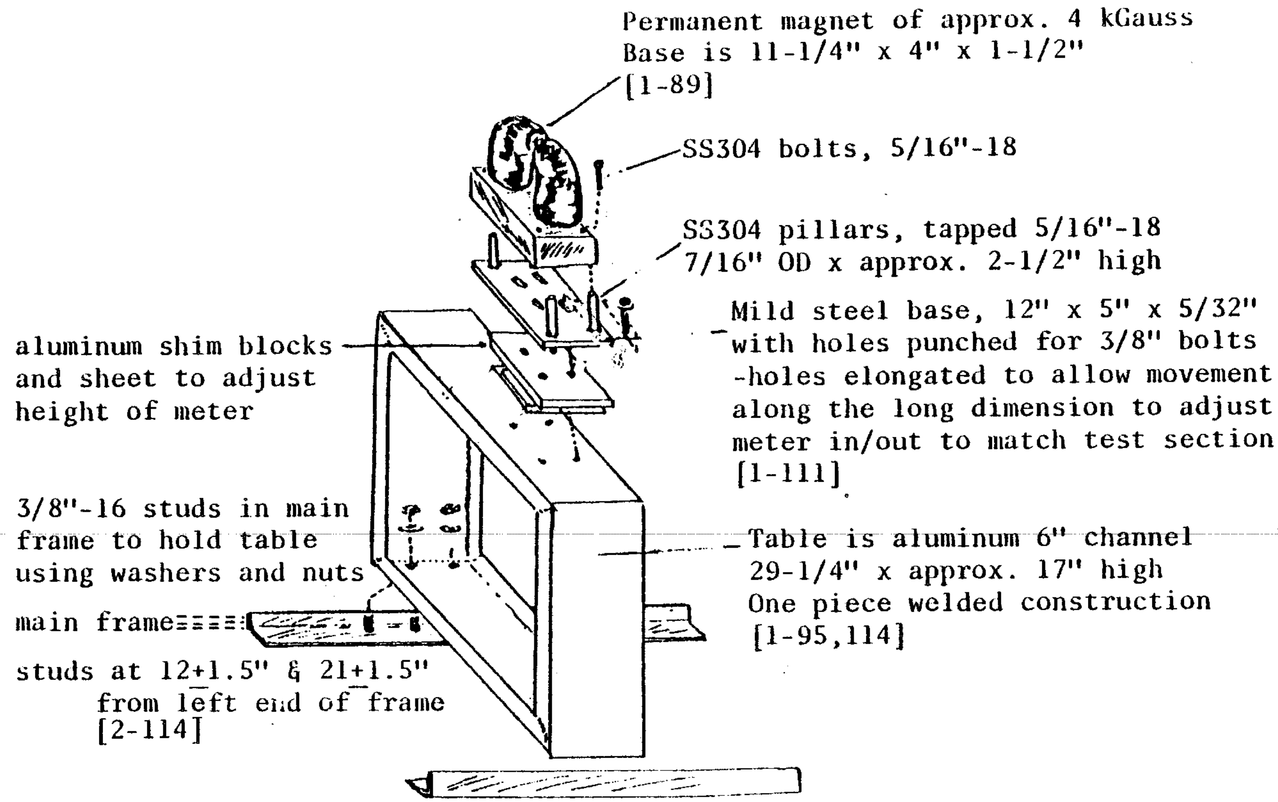
Fittings [2-59]

Hanger rod of 3/8" steel parallel to and 2" above manifold.
Manifold hangs by loops of .06" wire.
No clamps on manifold.

* Heater approximate cold resistance, watts at 120V, heated length
***Orientation on piping: U=up, D=down, L=left, R=right, F=front, B=back. Symbol < indicates direction in which the thermocouple is pointing, e.g., U<F is on upper side of pipe and points to front.



METER SECTIONS AND LOWER LITHIUM MANIFOLD



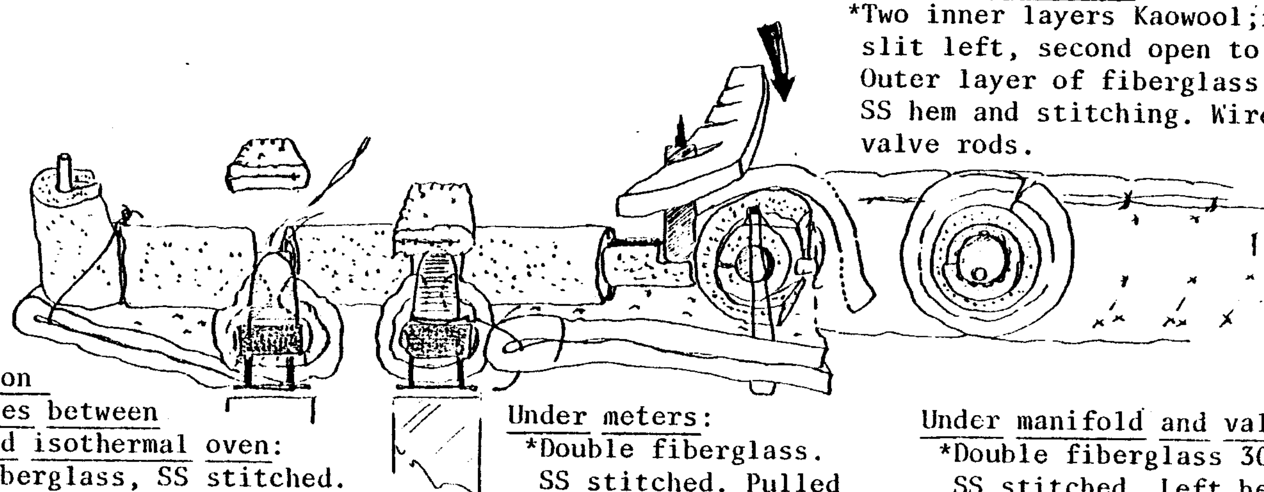
ELECTROMAGNETIC FLOWMETER AND TABLE

Test section insulation from valves to isothermal oven :
*Two layers of Kaowool-first layer slit up.
[2-110] second layer slit down.
*Gaps at each meter filled on top by double thick fiberglass,SS stitched, jammed into place [3-61]
Final layer double thick fiberglass, SS stitched, over entire area.

Valve cover [4-125]
*Fiberglass single thickness, SS hemmed. Valves each within open SS shim box.

Main heater insulation [3-58]:
*Twelve rings of ceramic beads on SS316 wire .02" diameter to hold heater clamshells off pipe.
*Three pairs of split clamshell heaters with longitudinal splits offset slightly to avoid interference of power leads. Power leads are ceramic-bead insulated.
*Heaters held at back by 6 SS power clamps.
*Inner layer Kaowool (one piece?)
*Outer layer double thick fiberglass,SS stitched, Penetrated through longitudinal slit by 4 type K TCs held to clamshell outside surface by power clamps.

Manifold insulation [3-131,137]
*Two inner layers Kaowool;first slit left, second open to right. Outer layer of fiberglass 8"x36" SS hem and stitching. Wired to valve rods.



Test section under pipes between meters and isothermal oven:
*Double fiberglass, SS stitched. Hangs by wire at left, jammed under meters at right [4-129].

Under meters:
*Double fiberglass. SS stitched. Pulled under meters and jammed between poles at top [3-61].

Under manifold and valves:
*Double fiberglass 30"x12". SS stitched. Left held by wires around meter pole bases.Right wired to heater hanger rod [3-135].

METER SECTIONS AND LOWER LITHIUM MANIFOLD

ISOTHERMAL ZONE AND FREEZE STANDPIPES

Heaters, chromized steel strip 1-1/2" wide, 240V maximum. [2-114]
Set 2" away from test sections on each side in two banks of three heaters each on 8" centers, horizontal placement.
#25,#26,#27 on right(inside) top to bottom 38Ω, 375W, 23-3/4"*
#28,#29,#30 left(outside) top to bottom 38Ω, 375W, 23-3/4"
terminals to back of oven (left as viewed from end of loop)

Thermocouples, #20 or #22 gauge chromel-alumel (type K) [2-132]
on alternate front/back sides of test sections. Positions given as distance below tee/coupon number : (5"/#16;9"/#12;13"/#8;17"/#4;21")
Thermocouple leads point upward.

Fittings
on each test section [top of isothermal zone] tee
[bottom of zone] stringer stop
tee is approx. 21-1/2" above stringer stop;
stop is approx. 7" above plane of meter sections;
oven extends from tee, down 24". (4" above; 2.5" below stringers.)

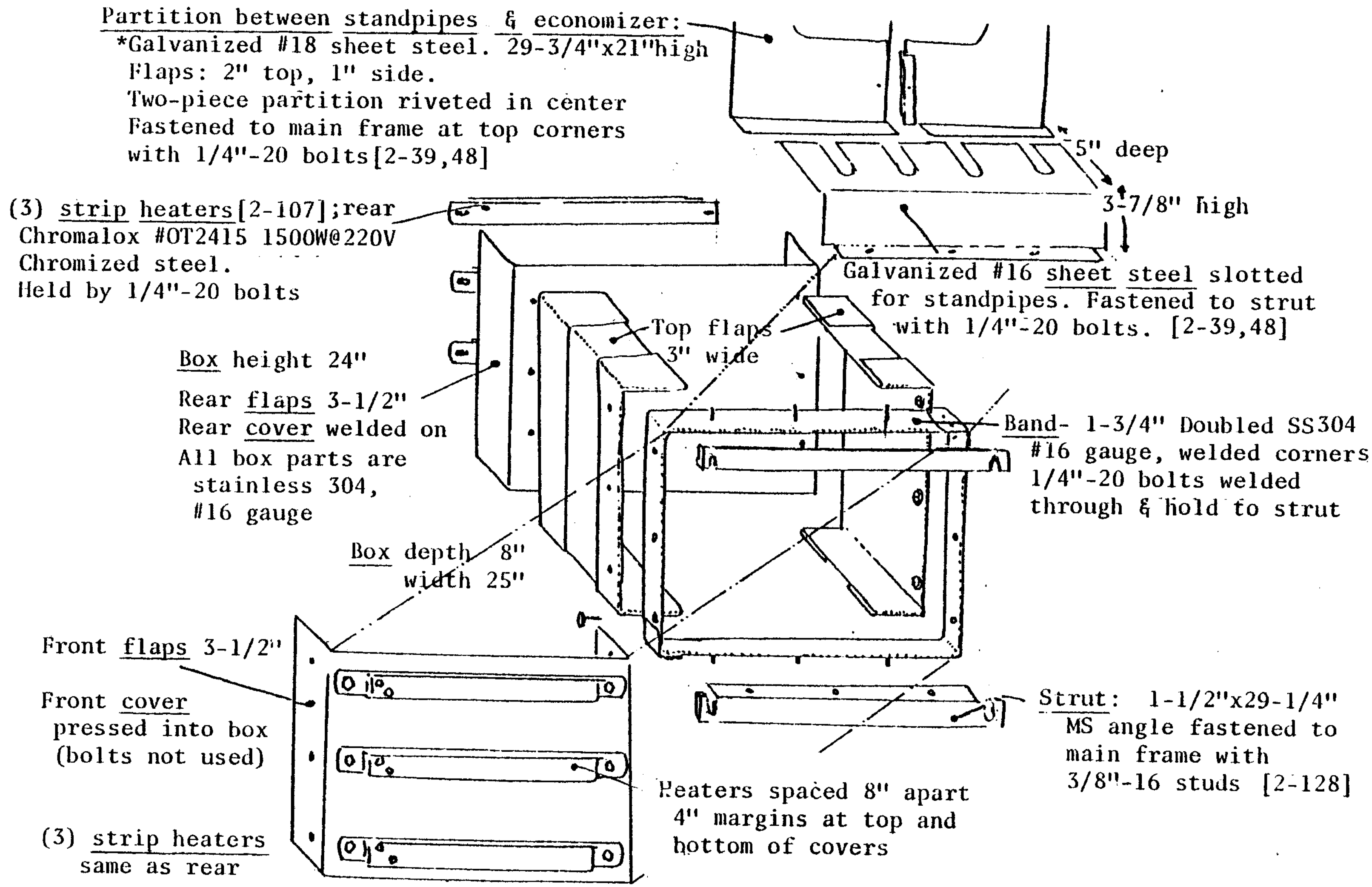
Heaters, tubular, .246" incoloy sheath, 240V maximum,
on each standpipe, front/back sides of pipe and extending up around lower ball valve and adapter pipe, terminals at top (adapter)
#X circuit serves all; 46Ω, 310W, 51"
on headers between test sections and upper lithium manifold, [1-94]
front/back sides of tubing and bottom/right sides of manifold.
#70 on back pair headers (1&2) 46Ω, 310W, 51" terminals to back end.
#71 front pair headers(3&4) 46Ω, 310W, 51" terminals to inside
[2-112] right and to manifold front end.
on manifold only, left/right sides, terminals to manifold back end
#69 (manifold only) 58Ω, 250W, 41"

Thermocouples, #18 gauge chromel-alumel (type K) [2-112]
middle inside of each header, pointing upward along header.
center-bottom of manifold, pointing to right (away from manifold)
top-side of manifold, near front & back, pointing front/back respec.
freeze standpipes, left (outer) side, points upward
at [4", 9", and 15"] down from ball valve flange (tee is 21" down)

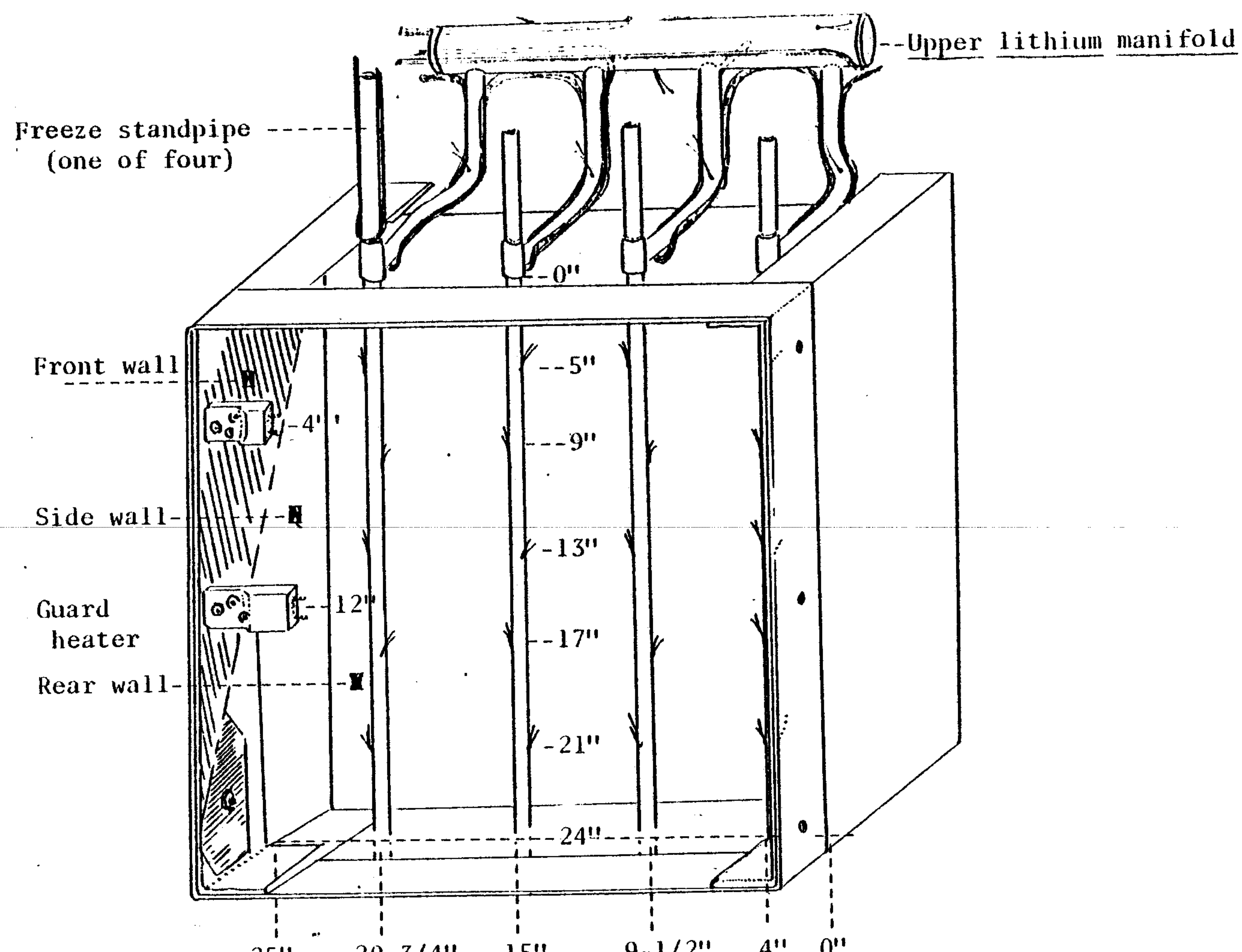
Wire ties, with shim stock underneath, stainless steel [2-112]
on headers, near tee and near manifold, twists near tee point up, twists near manifold generally point to front or back.
on manifold, between headers and at front, pointing upward.
on standpipes, pointing to left(out) as needed
on adapter pipes, power clamps hold heaters

Hangers: on manifold between headers 1 & 2, and 3 & 4. SS304 wire slings, .06" dia., from spring-loaded support rods to roof

*Heater approximate resistance, watts at 120V, heated length of tubular heaters, total length of strip heaters

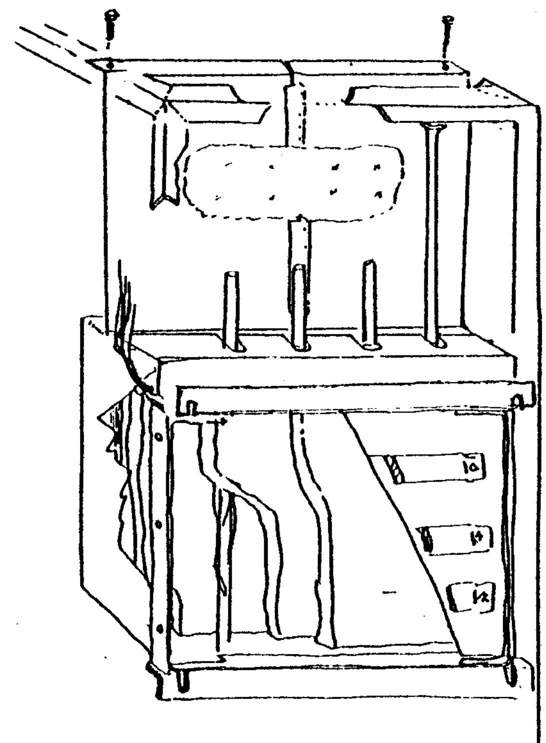


ISOTHERMAL OVEN -- EXPLODED VIEW [2-111]

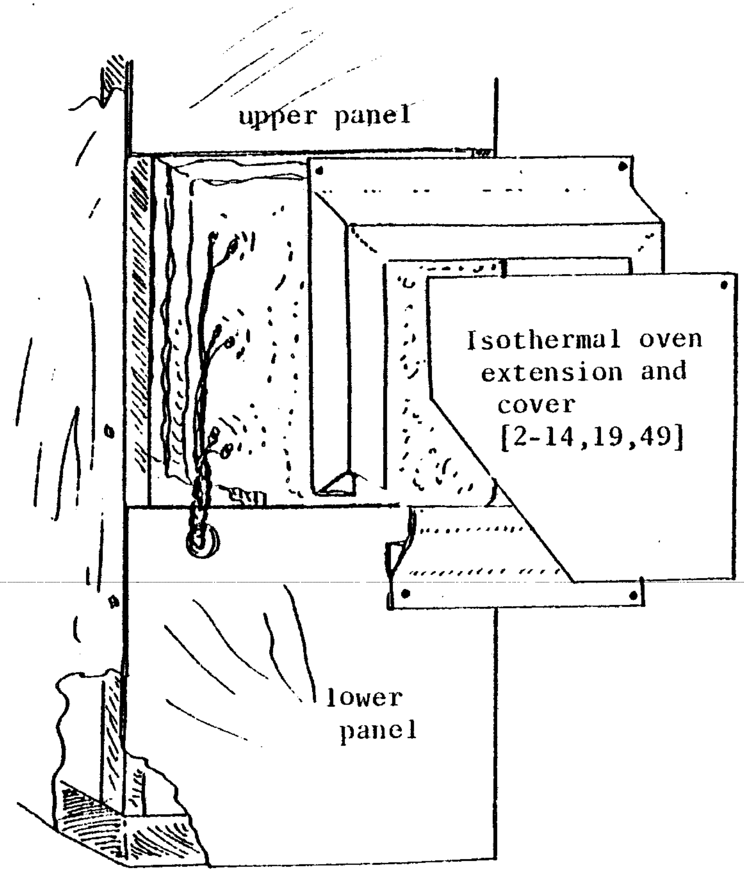


ISOTHERMAL OVEN -- INTERNAL VIEW SHOWING THERMOCOUPLES AND HEATERS

Note how thermocouple wires run along test section pipe until beyond the isothermal area and then emerge at the left side of the assembly. [2-111,116]

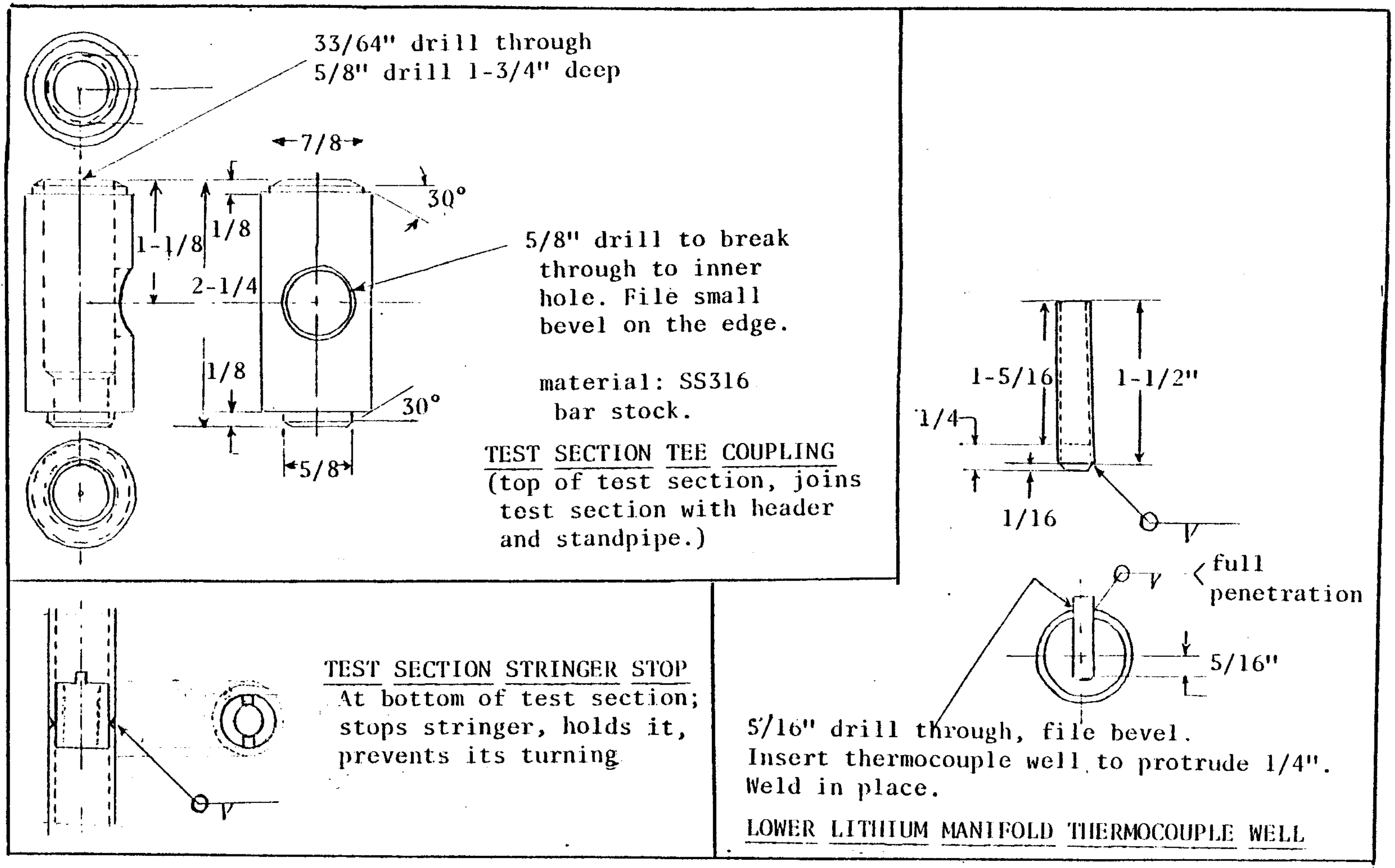


ISOTHERMAL OVEN -- ASSEMBLED, INTERNAL VIEW

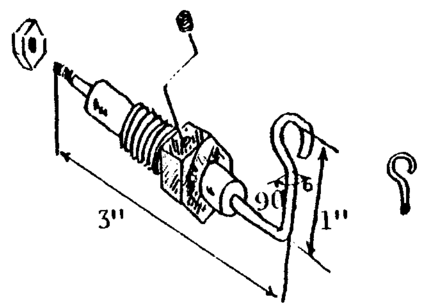


Isothermal oven, external view, from left end of loop. Note how the outside (left end) heater wires pass through the bottom panel. Disconnect heaters before removing bottom panel.

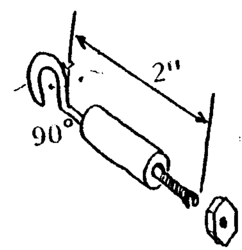
ISOTHERMAL OVEN, EXTERIOR VIEW



TEST SECTION TEE, STRINGER STOP; AND LOWER MANIFOLD THERMOCOUPLE WELL



Radiator heater lug

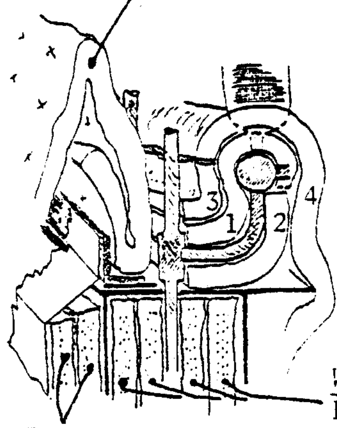


Isothermal oven heater lug

Both types have ceramic tubular insulator, 5/16" OD with 1/8" hole. Conductor is stainless steel 1/8" rod, 6-32 threads on cold end. Loop on hot end is 90° to plane of the "ell" in the wire. Loop is for connection to heater terminal. Lugged power lead is held on cold end between 2 nuts. Radiator lug passes through sheet metal housing; held inside a 1/2"-13x1" bolt drilled out for ceramic tube. Bolt secured outside housing with nut. Tube secured lightly by set screw through bolthead flat. Bolt head is <u>inside</u> radiator housing. [2-127]

HEATER TERMINAL LUGS FOR STRIP HEATERS INSIDE RADIATOR OR OVEN

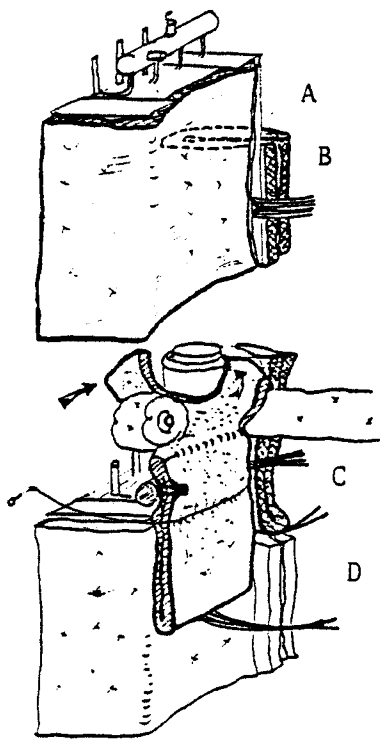
Freeze zone blanket fiberglass.
Folded up or down as needed [4-125]



Top manifold & exit headers: 4 pieces Kaowool as shown [2-110]

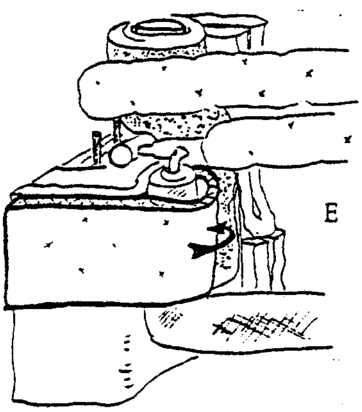
Within isothermal oven: Four batts of Kaowool; two batts on each side of test section pipes.

Extension panel: (of oven) two batts of Kaowool.



INTERNAL INSULATION OF OVEN

As shown above. Surge tank also insulated. Shimstock of headers as per [2-112]. Header thermocouples as per [2-112]. Test section thermocouples per [2-132].

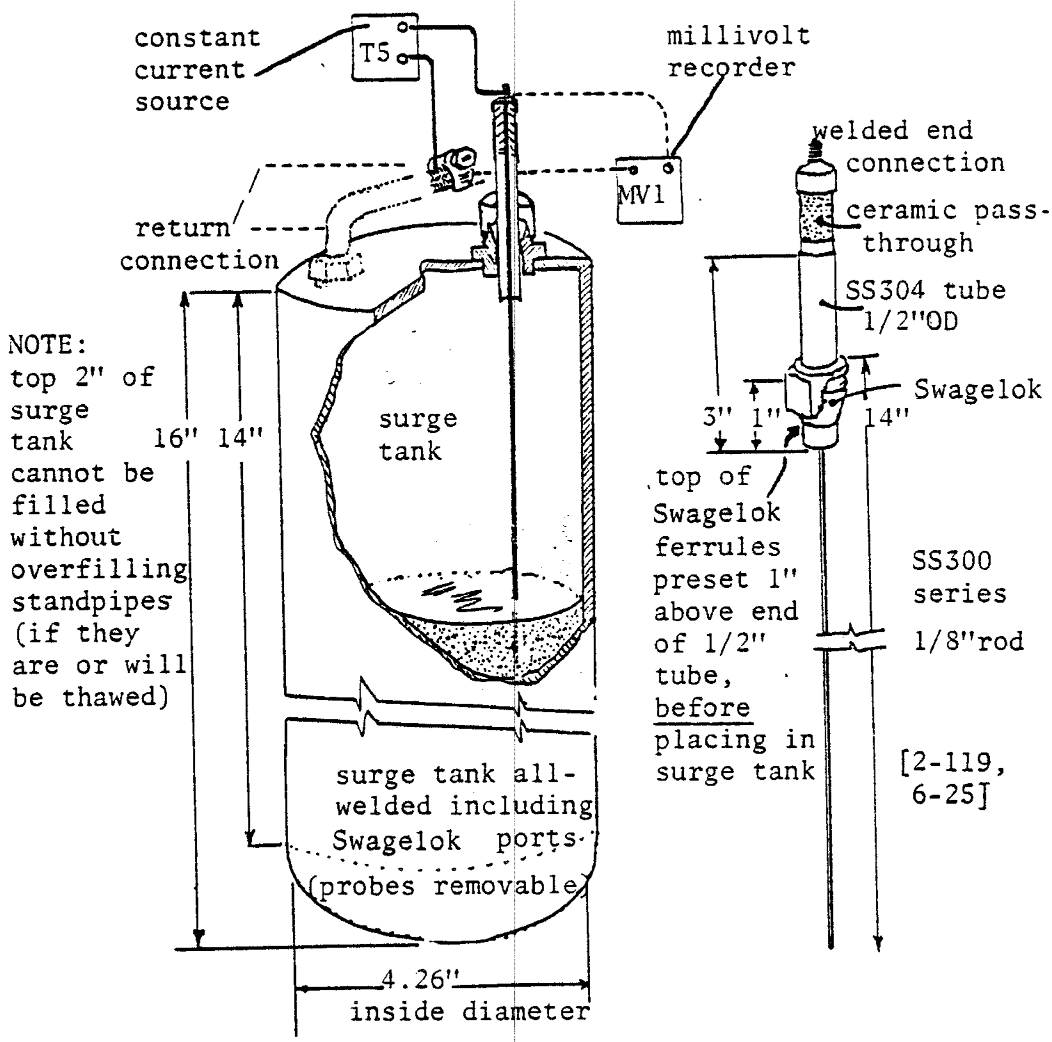


EXTERNAL INSULATION [3-62, 3-134]

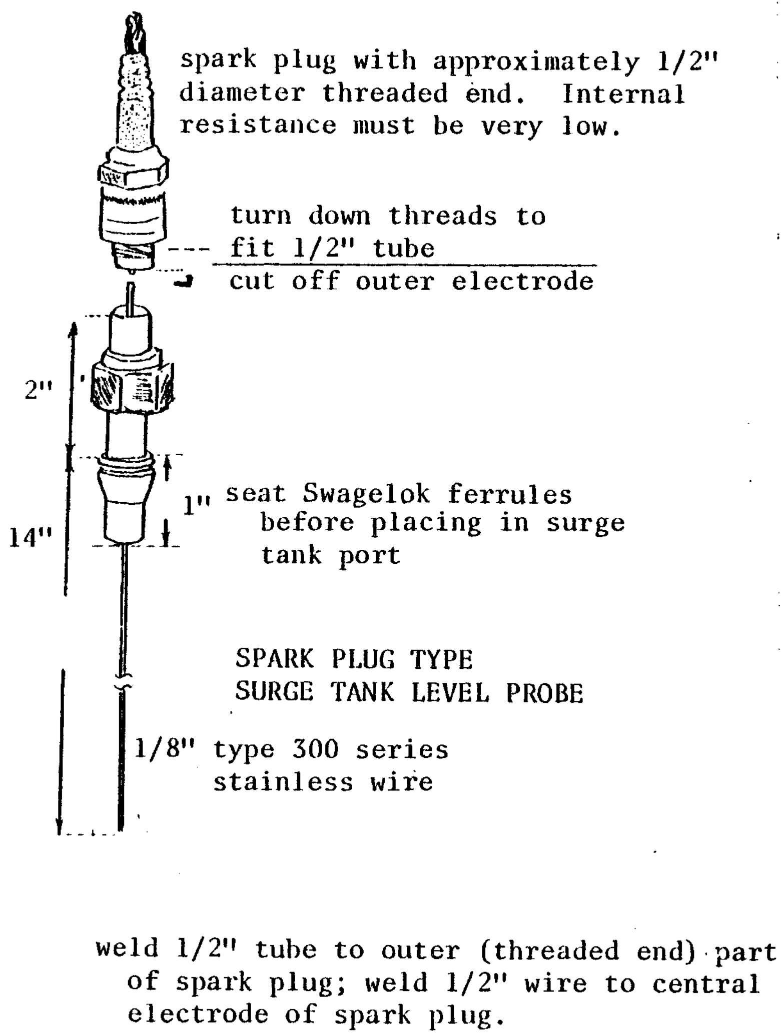
As shown in three drawings to left.

A. One thickness fiberglass front & right side of oven (as seen from front, long, side of loop).
B. Two thickness fiberglass back. At junction with "A" are wires to oven strip heaters #25,27,29 (top to bottom).
C. Two thickness fiberglass, back of manifold/economizer crossover. Rests on "B". Manifold heater #69 wires at B/C junction.
D. Two thickness fiberglass, two parts: top 30" x 12" Stainless wire-hemmed, stainless wire stitched to lower drape. Top wraps around the surge tank. Bottom held in by wire to frame bolts. Manifold heater #71 wires @ C/D; manifold #70, econ #78 @A/D.
E. One thickness fiberglass around pipe at right, between oven and frame at left. At A/E junction, wires to #72,73,74,88,89.

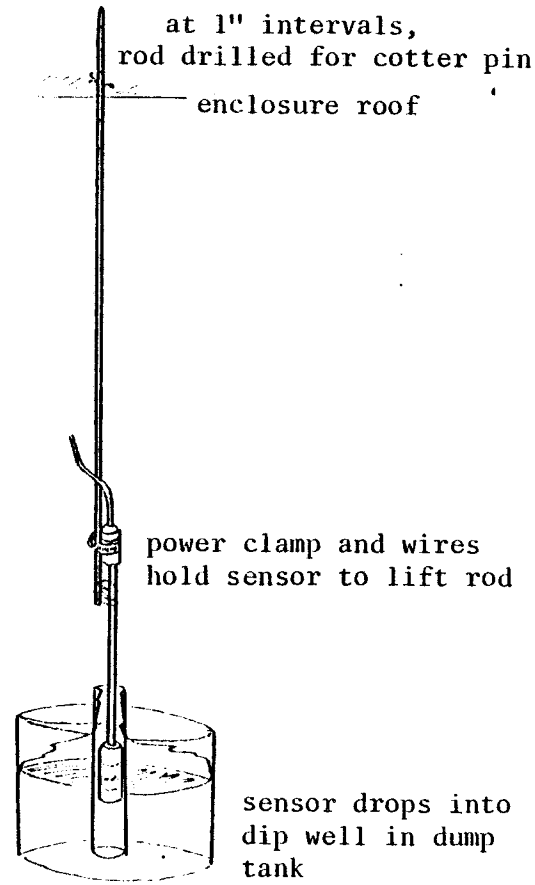
ISOTHERMAL OVEN INSULATION



SURGE TANK AND LEVEL PROBE



SPARK PLUG TYPE
SURGE TANK LEVEL PROBE



DUMP TANK LEVEL PROBE

LITHIUM LEVEL DETECTORS FOR SURGE TANK AND DUMP TANK

ECONOMIZER

Heaters, tubular, .246" incoloy sheath, 240V maximum [2-82]
Terminals for lower front section:
#72 Z8=[0"] U #73 [0"] F #74 [0"] B
#72' [8'8"] U #73' [8'6"] F #74' [8'10"] B
Terminals for back section:
#75 Z8=[8'3"] U #76 Z8=[8'5"] B #77 Z8=[8'4"] F
#75' Z9=[7'4"] L #76'Z9=[7'0"] L #77'Z9=[7'3"] R
Terminals for upper front section:
#78 Z9=[6'11"] UR #79 Z9=[6'7"] UL #80 Z9=[6'7"] DL
#78' [end] UB #79' [end] FR #80' [end] BD
all heaters are ------------- 23Ω. 625W@120V, 102" heated length.
and are shim-stocked (spot-welded) near thermocouples.

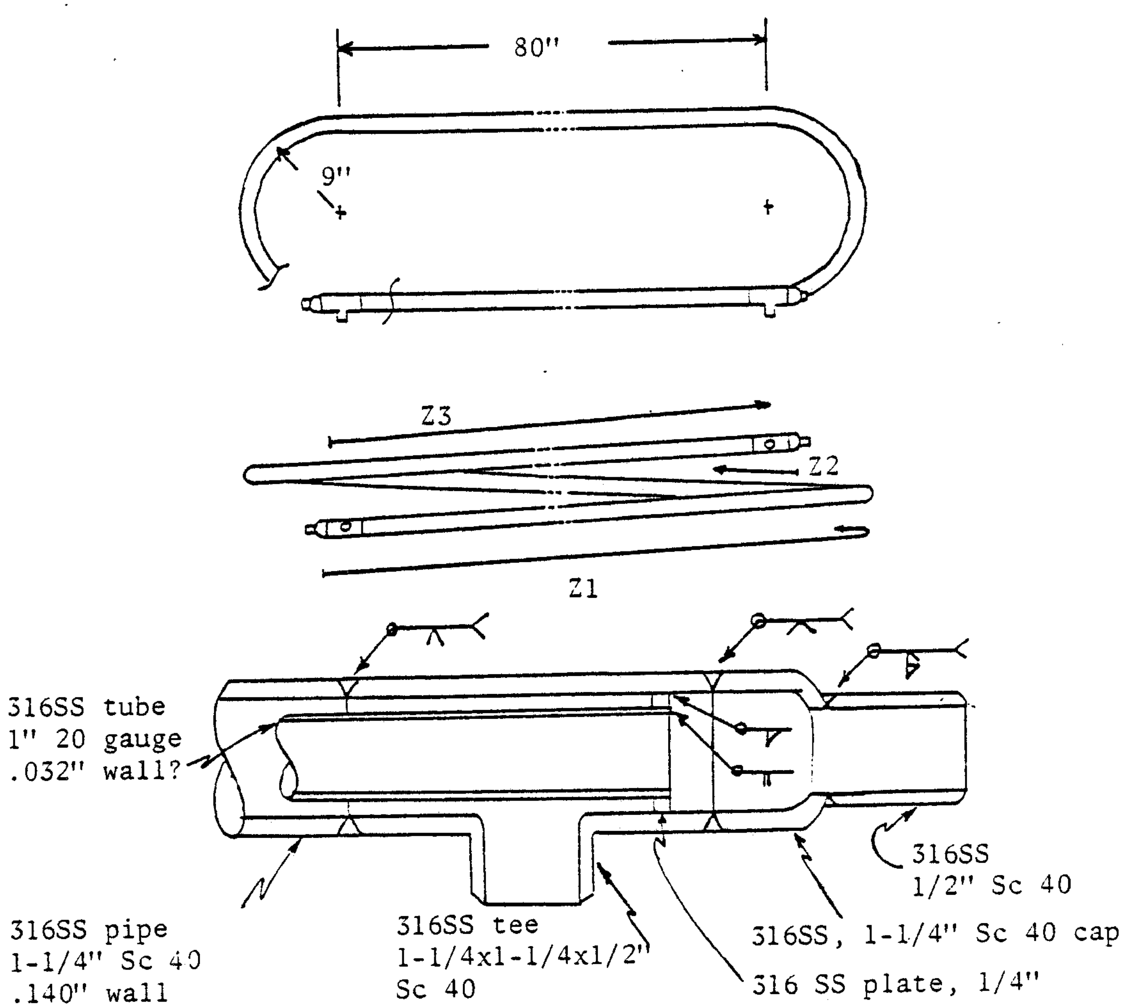
Wire ties, stainless steel 304, .06" diameter. Twists located to upper, outer side of economizer at one foot intervals along Z8-Z10.
Exceptions are: Twists under pipe: Z8=[0',1',7'2",8'5",8'9"]
Z9=[6'6",7'1"]
on upper-outer side of pipe: Z8=[7'2"], Z9=[10",4'11",7'10"]
manufacturer's nameplate : Z9=[11-16"]

Thermocouples, 18 gauge chromel-alumel (type K) [2-83]
Lower front section: distance along Z8
[5.5"]UF+UB<R [2'6"]UF<R [4'6"]UF<R+L
[5'8"]UF<R [7'10"]UF+UB<B [9'11"] Z9=0 starts
Back section: distance along Z9
[7"]UB<L [1'6"]UB<L [3'6"]UB<R+L [4'6"]UB+UF<L
[5'5"]UB+UF<R [7'3"]B<L [8'4.5"] Z10=0 starts
Upper front section: distance along Z10
[6"]UF+UB<R [2'6"]UF<R [4'6"]UF<R+L [5'8"]UF<R

Clamps, power type, stainless steel. Screw on pipe bottom, head out. [2-83]
Lower front section, Z8=[1.5',3.5',5.5']
Back section, Z9=[0.5',2.5',4.5']
Upper front section, Z10=[1.5',3.5',5.5']

Hangers, SS304 wire, 0.06" slings from spring-loaded support rods [2-83]
Z8=[2",6'5",9'4"(back corner)]
Z9=[5'10] Z10=[2",6'6"]

*Orientation on piping: U=up, D=down, L=left, R=right, F=front, B=back. Symbol < indicates direction in which thermocouple leads point. UF+UB < R means thermocouples are placed at upper front and upper back of pipe, and their leads point to the right.



ECONOMIZER--DRAWING BY MSA COMPANY

ECONOMIZER INSULATION [2-109]

Straight parts of economizer (three)
Inner layer Kaowool, 2 foot sections, seams to upper outside.
Second layer fiberglass, continuous from end to end (about 8 feet) except for front bottom straight section, which is in parts.

The back economizer section's second layer of insulation is seamed to the upper inside, slightly above center. This insulation is packed tightly against the insulation of the back of the radiator.

The front upper economizer section's second layer of insulation is seamed to the lower back. Where necessary at the left of the main heater, the insulation is slitted on top and bottom edges to accommodate hanger rods passing near economizer and through insulation.

The front lower economizer section's second layer of insulation is seamed to the back and otherwise similar to the top section except that it is not a continuous piece.

The front straight parts of the economizer are in the same vertical plane, and a third layer of insulation, fiberglass batts 36" long, is hung over the front straight sections. From left to right, batts are 8,8,24 and 24 inches wide (accommodating hanger rods which pass near economizer).[3-137]

Turns of economizer (two) at ends
The economizer's 180°, 9" radius, turns are insulated entirely with fiberglass due to difficulty in forming Kaowool around turns.

Inner layer both ends, is seamed to the inside of turn.
Second layer is spiral-wrapped around the turn. Width of the piece of insulation is about 8". The left end turn, near the surge tank, spirals from the back to the extreme left of the economizer. A continuous non-spiraled piece covers the extreme left end to the straight, upper front section. This last piece is split to the inside of the turn.
The right end turn is wrapped with a front-to-back spiral.
An extra drape of insulation is between the left front upper corner of the economizer and the economizer [4-126].

DUMP SYSTEM (RIGHT END) PIPING

Heaters, tubular, .246" incoloy sheath, 240V maximum [2-114]*

#91	on economizer to radiator supply piping, top/bottom sides, terminals at radiator housing	46Ω, 310W, 51"*
#92	radiator to economizer return piping, left/right sides, terminals near radiator	23Ω, 625W, 102"
#93	cold trap, left/right sides, terminals at top, shim-stocked; no insulation	46Ω, 310W, 51"
#94	"upper" drain piping, left/right sides, terminals at dump tank	29Ω, 500W, 81"
#95	"lower" drain piping, front/back sides, terminals near main heater	46Ω, 310W, 51"

Wire ties, shim stock underneath, stainless steel [2-84]

Z1= [6",17.5,22,23.5] F**	Z2= [.5,5.5]U+D,no shim [8.5] B
Z3= [1] B,no shim, [6,13.5]R [20] F	Z4= [2,16] U [9,21] U+D, noshim
Z5= [as needed]	Z6= [..?..]

Thermocouples, #18 gauge chromel-alumel (type K)

Z1= [12,27] F<U	Z2= [2] U<B, [12,valveblock] B<U
Z3= [9] R<F [24] F<R	Z4= [6] U<B, [20]F<R
Z5= [2.5,6.5,10.5,14.5,18.5]B<U	Z6= [3.5,valve]U<F, [15.5]U<L

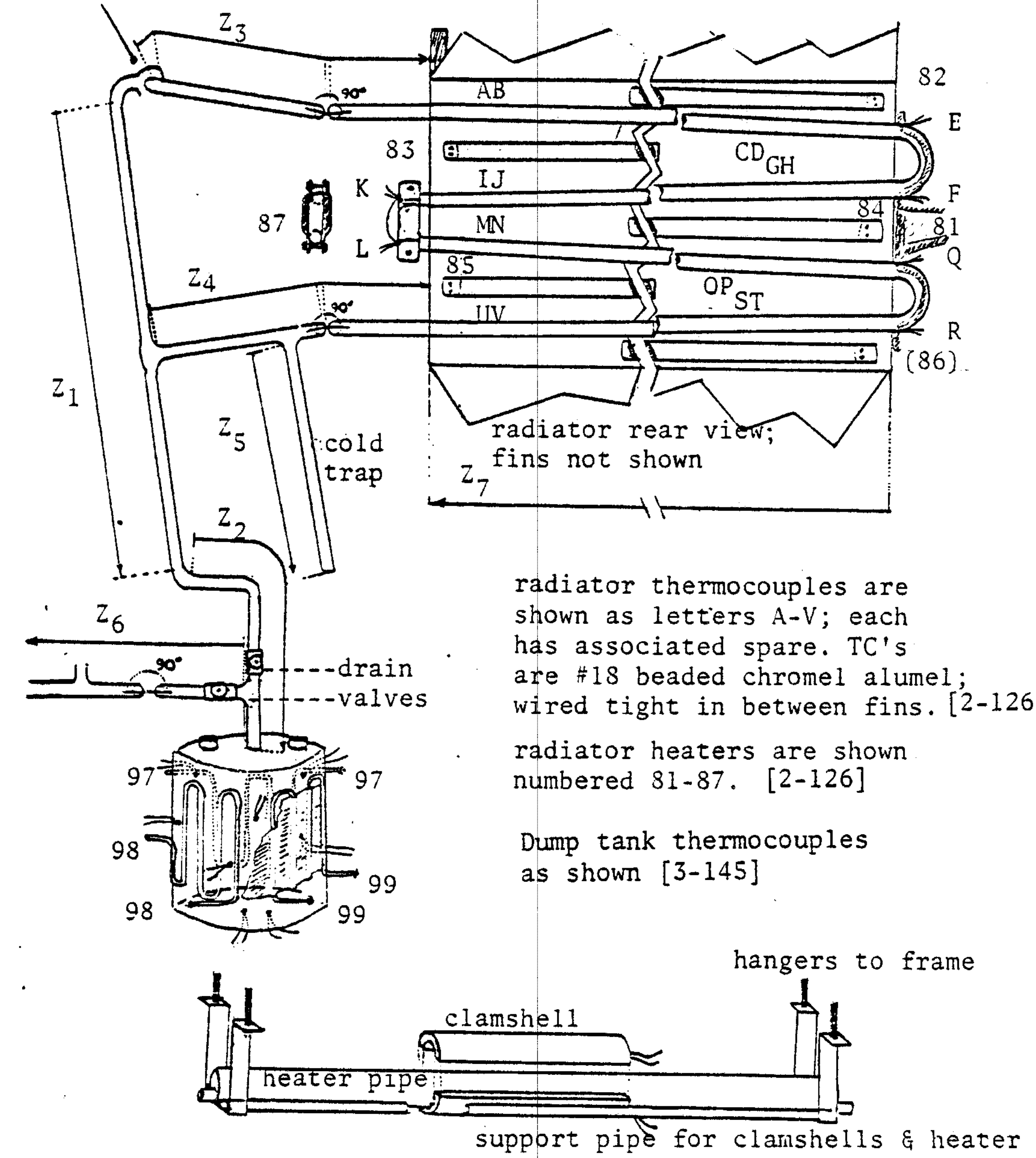
Z7= [on radiator: pairs on U-bends and 1/3, 2/3 each pass] [2-126]

Clamps and fittings [2-84]

Z1= [12,28] F<R clamp, [19.5] tee, [33] ell	Z2= [5.5] elbow [12] valve
Z3= [3,16] elbows, [11] R<U clamp	Z4= [10.5] tee [13.2] elbow
Z5= [.....]	Z6= [3.5] valve,[7.5] elbow [12] tee, [16.5] main heater

* Heater approximate resistance, watts at 120V, heated length.

** Positions along coordinates Z1, Z2, etc. as shown on diagram. Orientation on piping: U=up,D=down, L=left,R=right, F=front, B=back. Symbol < indicates direction in which thermocouple leads or clamp screw head points, e.g., R<F on right, points front.

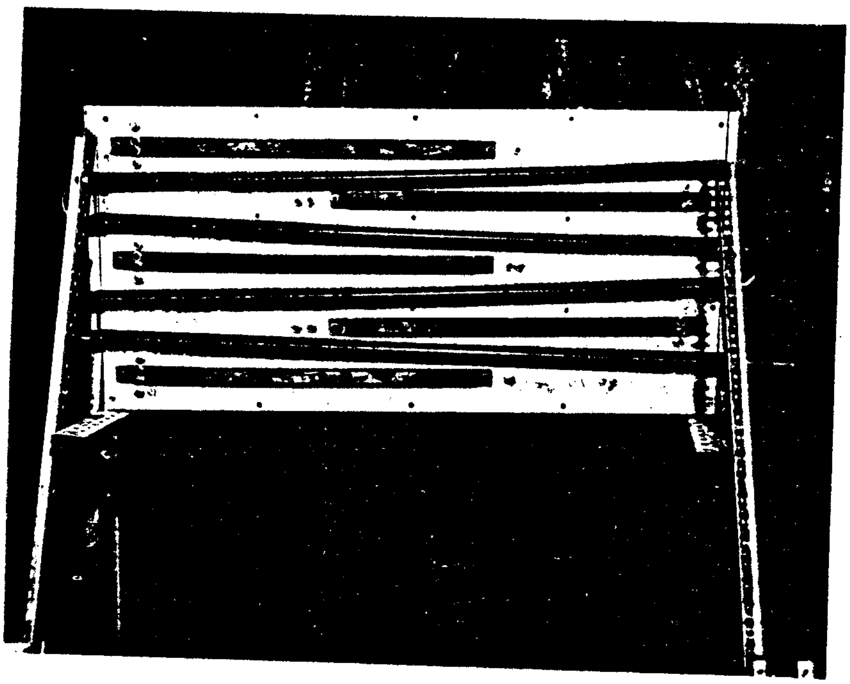


radiator thermocouples are shown as letters A-V; each has associated spare. TC's are #18 beaded chromel alumel; wired tight in between fins. [2-126]

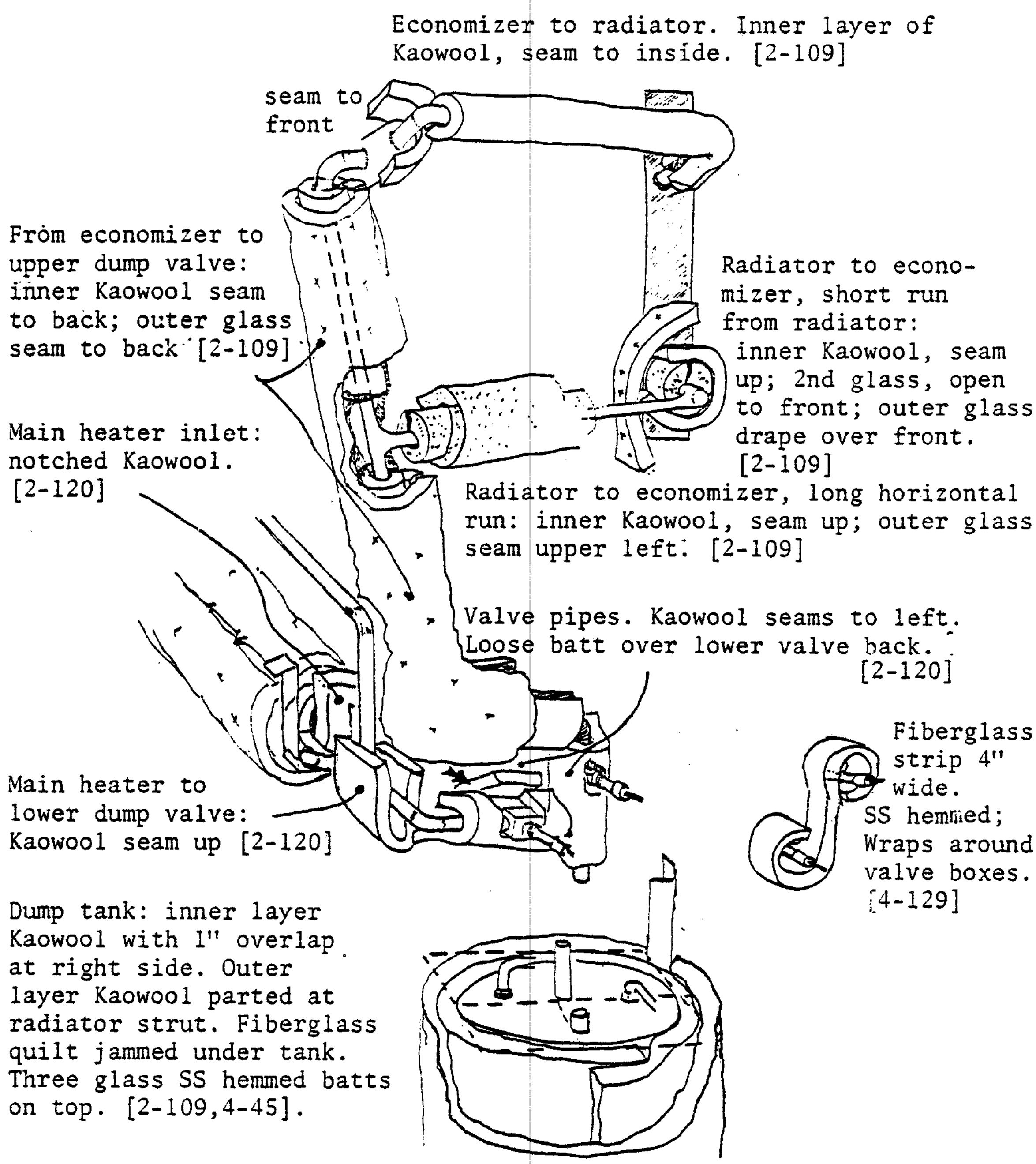
radiator heaters are shown numbered 81-87. [2-126]

Dump tank thermocouples as shown [3-145]

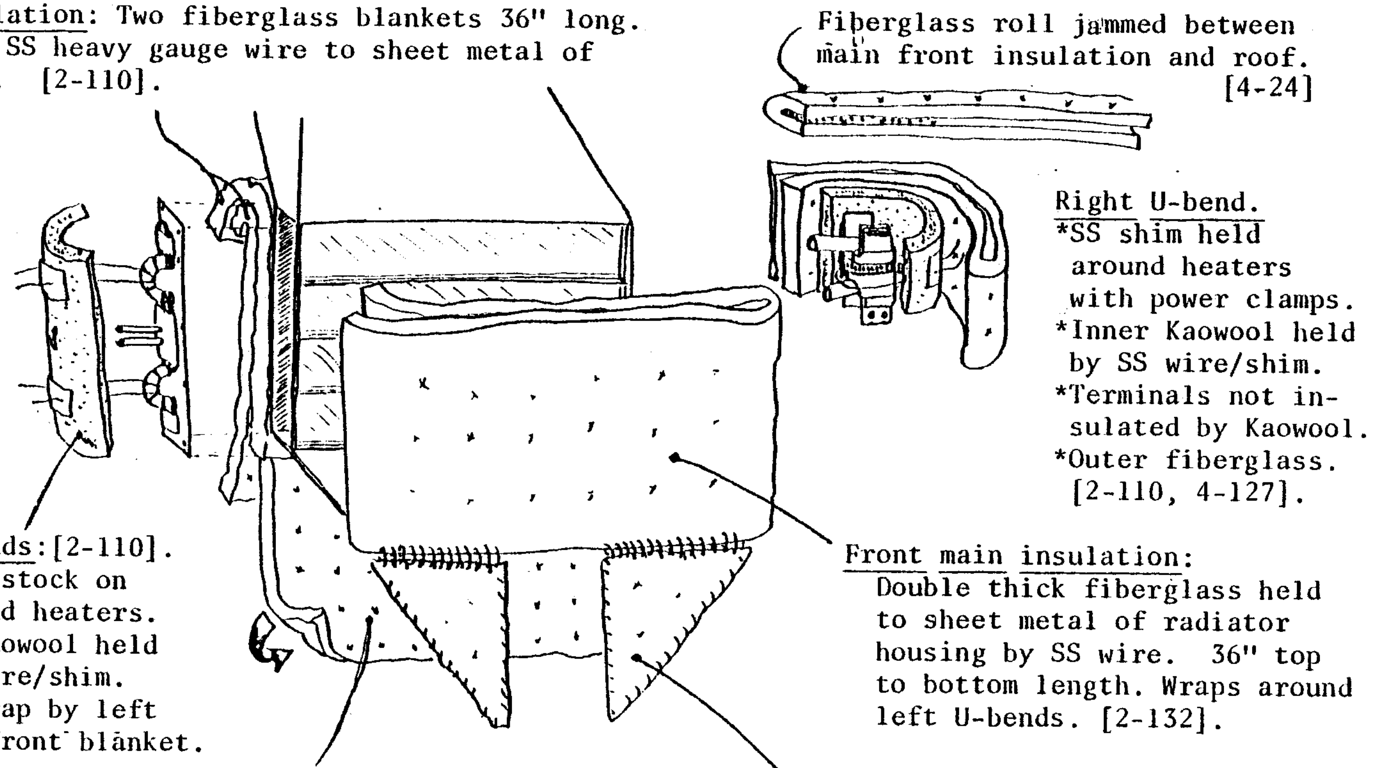
HEATERS--DUMP SYSTEM,MAIN HEATER,RADIATOR



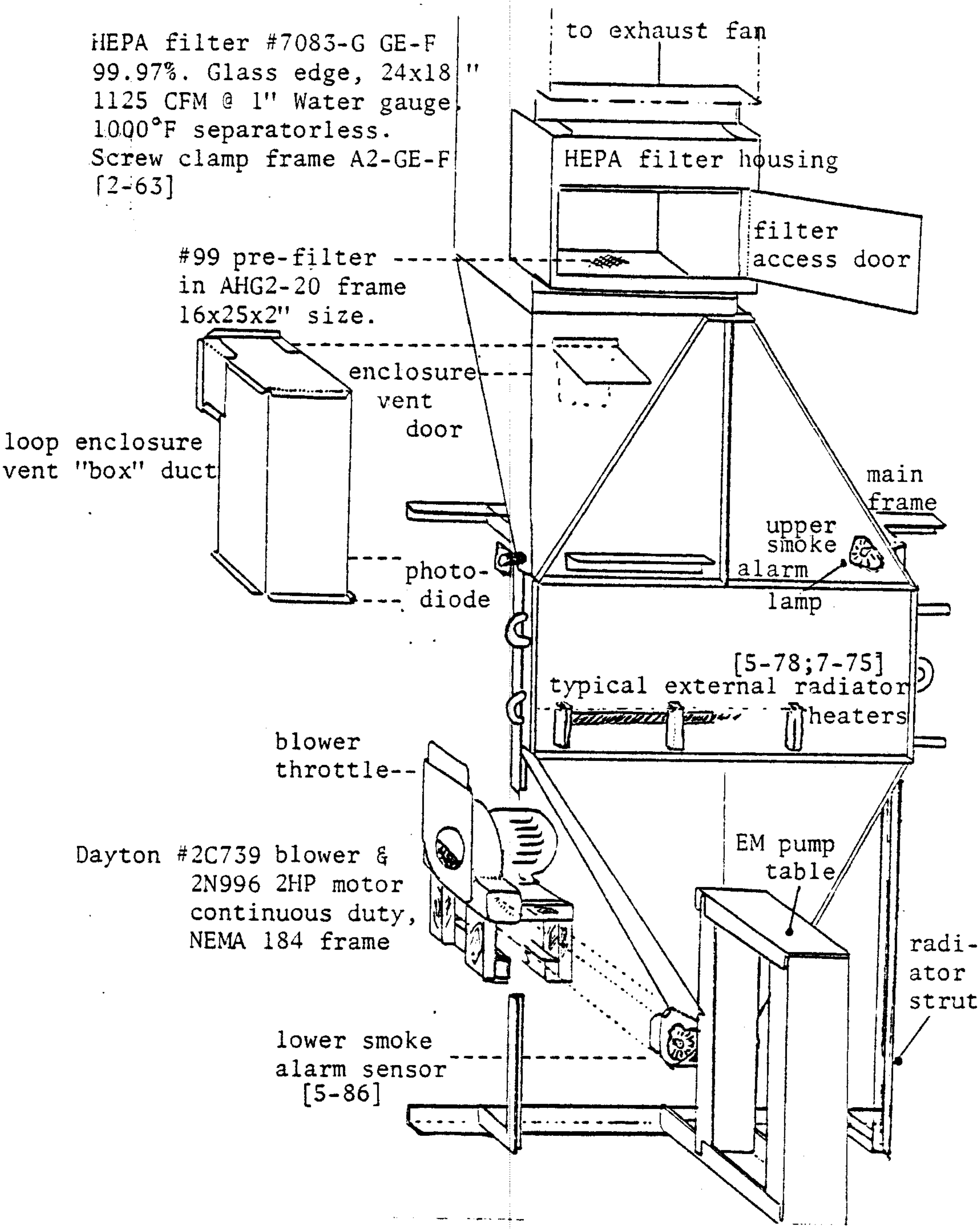
RADIATOR BEFORE INSTALLATION INTO LOOP



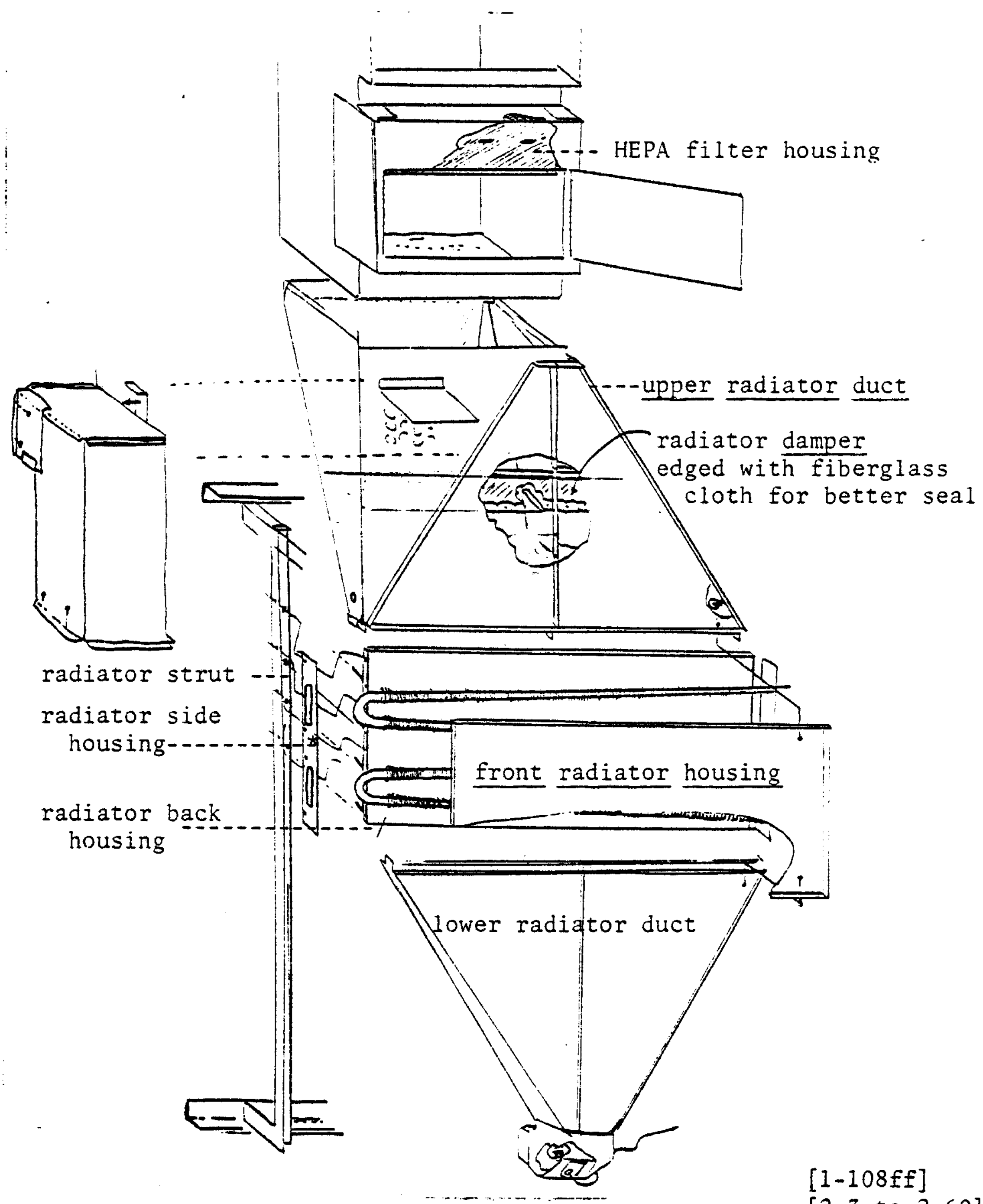
DUMP SYSTEM (RIGHT END) PIPING



RADIATOR INSULATION



LITHIUM LOOP VENTILATION SYSTEM.



[1-108ff]
[2-3 to 2-60]

VENTILATION SYSTEM--EXPLODED VIEW

TANKS, MAIN HEATER, AND RADIATOR

Dump tank

Heaters, tubular .246" incoloy sheath, 240V maximum [4-47]
#97,#98,#99 CCW order from left side 23Ω, 625W, 102"*
Heaters shim stocked as per diagram with shim spot-welded to tank.
Thermocouples, 18 gauge chromel-alumel (type K). Total of 10, as shown on diagram. [3-145]
Dump tank rests on four 5/8" ball bearings in 2 left/right channels.
Dump tank has 1/2" lithium fill and gas tubes, probe well, dump pipe.

Surge tank

Heater, tubular .31" incoloy sheath (non-standard for loop)
#68 wound spirally on tank 17Ω, 750W, 90"(?)
Heater held to tank by spot-welded small strips of SS302 shimstock.
Thermocouples, 18 gauge chromel-alumel (type K). [3-40]
[5" below top]L<D, [8" below top] R<D
Surge tank has three level probes in top; 3/8" gas connection.
Surge tank is not externally braced; pipe connection to manifold. [4-144]

Main heater (Using Thermocraft #RH256 clamshells) [3-4,58]

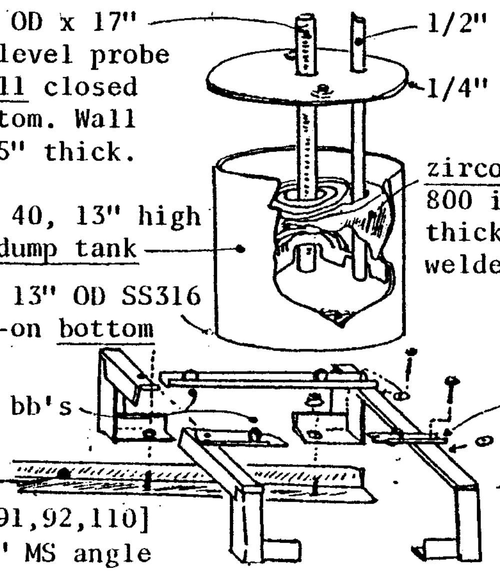
Clamshell heaters, ceramic potted type, 18" long, 3" ID, 4" OD. [3-4]
Three pairs of heaters cover 54" heater pipe, held off pipe by small ceramic beads strung on SS316 wires. Term. wires bead-insulated. [3-58]
#A-#F six heaters left to right on pipe 33Ω, 1730W@220V, 18" long
Clamshells held by stainless steel power clamps.
Thermocouples, 18 gauge chromel-alumel (type K)
three thermocouples on left (outlet) end (1 direct connection to overtemperature safety indicator), one thermocouple on inlet end.
Main heater clamshells supported on two 1" stainless steel pipes running parallel under heater. These supported in straps from spring loaded rods (2 at each end) to enclosure roof. [2-122]

Radiator

Heaters: tubular, .246" incoloy sheath, 240V maximum [2-126]
#81 on left U-bends front/back of piping, terminals extending to left between U-bends 58Ω, 250W, 41"
strip heaters, steel sheath, 120V maximum, 1-1/2" wide
#87 on right U-bend front/back of piping, two paralleled heaters, terminals to bottom, 2@ 300Ω, 50W ea, 6"
strip heaters, chromized steel sheath, 240 V maximum inside radiator housing; terminals to outer end:
#82,84,(86 burned out) Z7=[3 to 30] 38Ω, 1500W@240V,26"
#83,85 Z7=[20 to 48] 38Ω, 1500W@240V,26"
#86 outside radiator, paralleled pair 28Ω, 2000W@240V,38"

Thermocouples, 18 gauge chromel-alumel (type K) wired between fins with .05" SS304 wire ties on each finned pipe at Z7=[16,17,33,34"]. Run out through back of radiator housing. Also 2 TCs spot-welded on each U-bend. Wireties and shim stock on U-bends. [2-110]

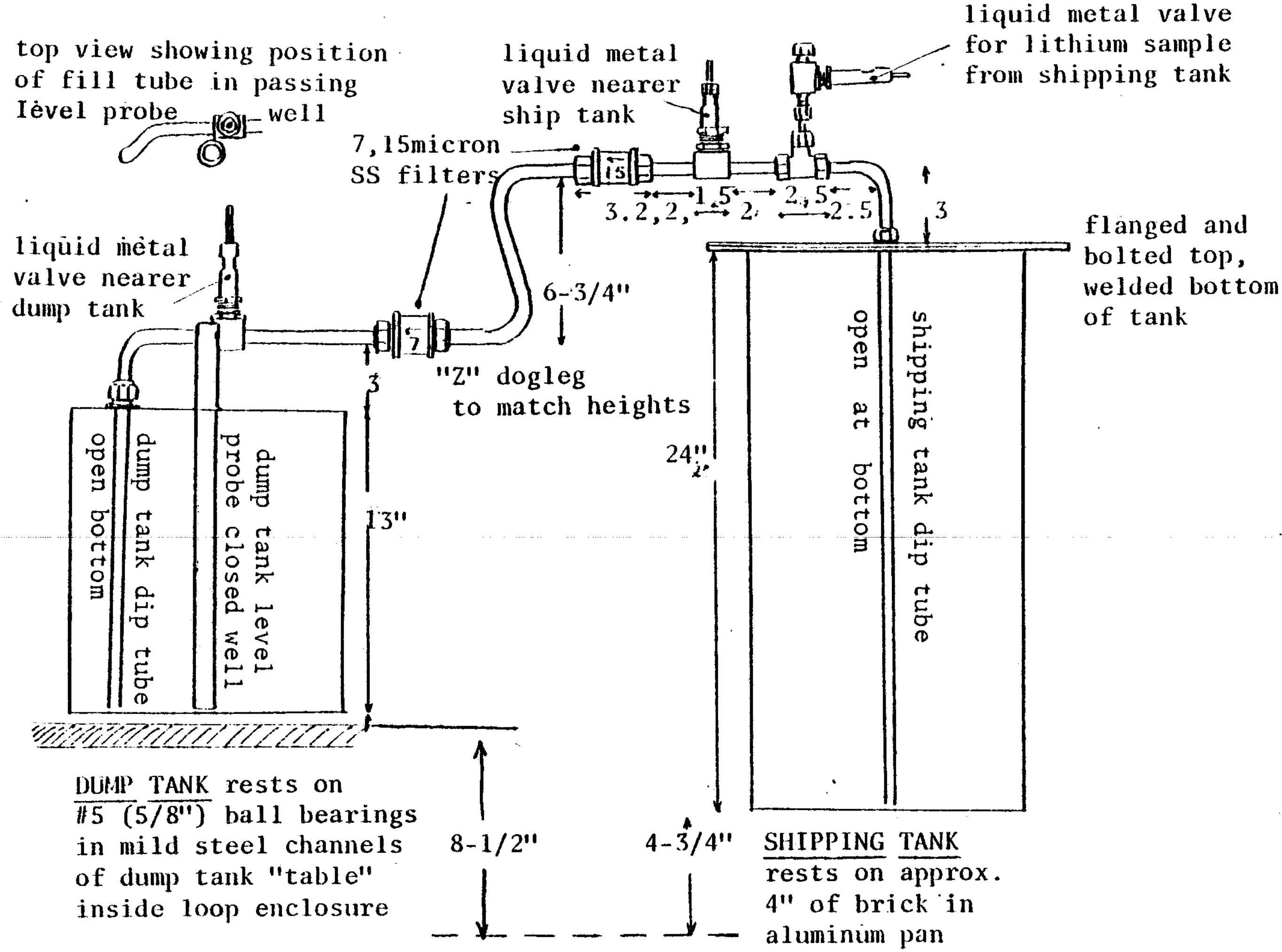
*Heaters: resistance, wattage, heated tubular or total strip length.



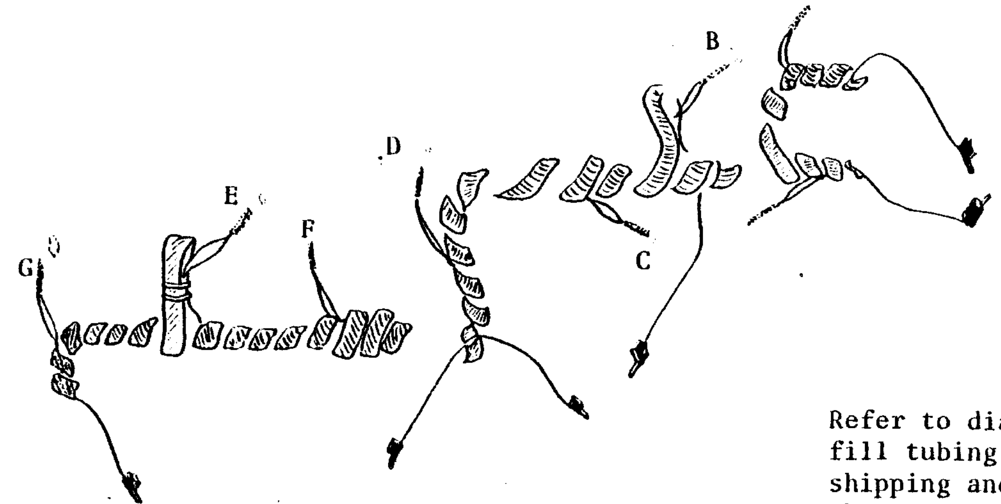
dump tank table: [1-91,92,110]
ends 1-1/2" x 3/16" MS angle 29-1/4" across, 6-3/16" high each end welded in one piece. Fastened to main frame with four 3/8" studs.
channels 1"x1/2" MS (mild steel) 18" long, hold bb's supporting dump tank. (four ball bearings).

Also reference:
- Heating [1-99,110,2-84]
- Shipping tank [2-85,129]
- Titanium holder [2-120,128]
- Titanium, 99.5% [2-101,128]
- Ship-to-Dump tank transfer tubing [3-76ff]
- Dump tank [1-79,97]

DUMP TANK CONSTRUCTION



DUMP TANK AND SHIPPING TANK: CONNECTIONS [3-76ff,90ff; 4-33 to 47]

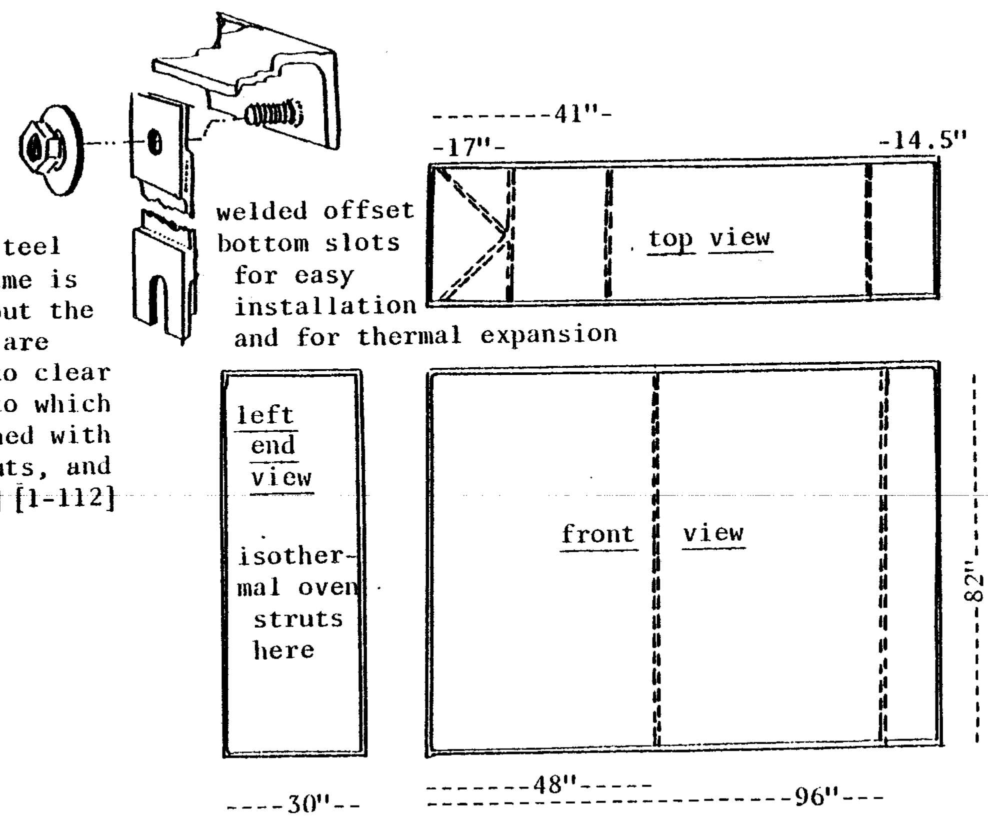


Refer to diagram of fill tubing between shipping and dump tanks, shown on previous page. This diagram superimposed on previous diagram gives heater configuration.
[4-45]

DUMP TANK AND SHIPPING TANK--HEATING TAPE AND THERMOCOUPLE SCHEME

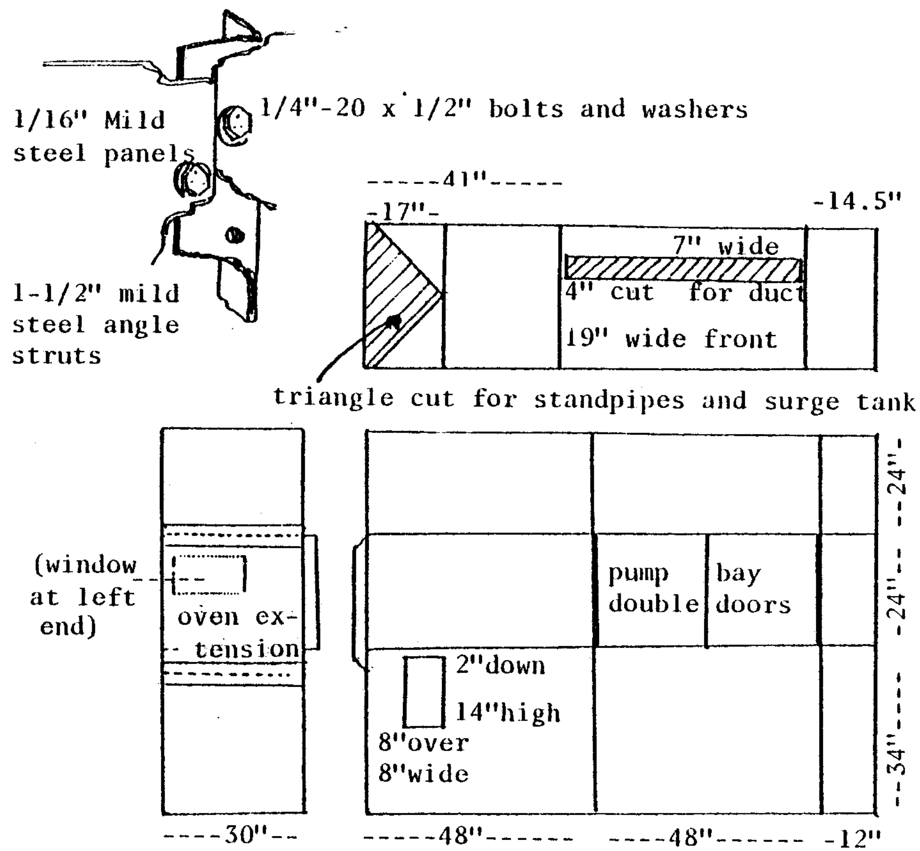
APPENDIX C. ENCLOSURE FRAMING AND PANELING

Struts are mild steel 1-1/2" angle (frame is 2" angle). All but the "K" strut on top are offset as shown to clear the main frame, to which struts are attached with 3/8"-16 studs, nuts, and washers. [2-8,15] [1-112]

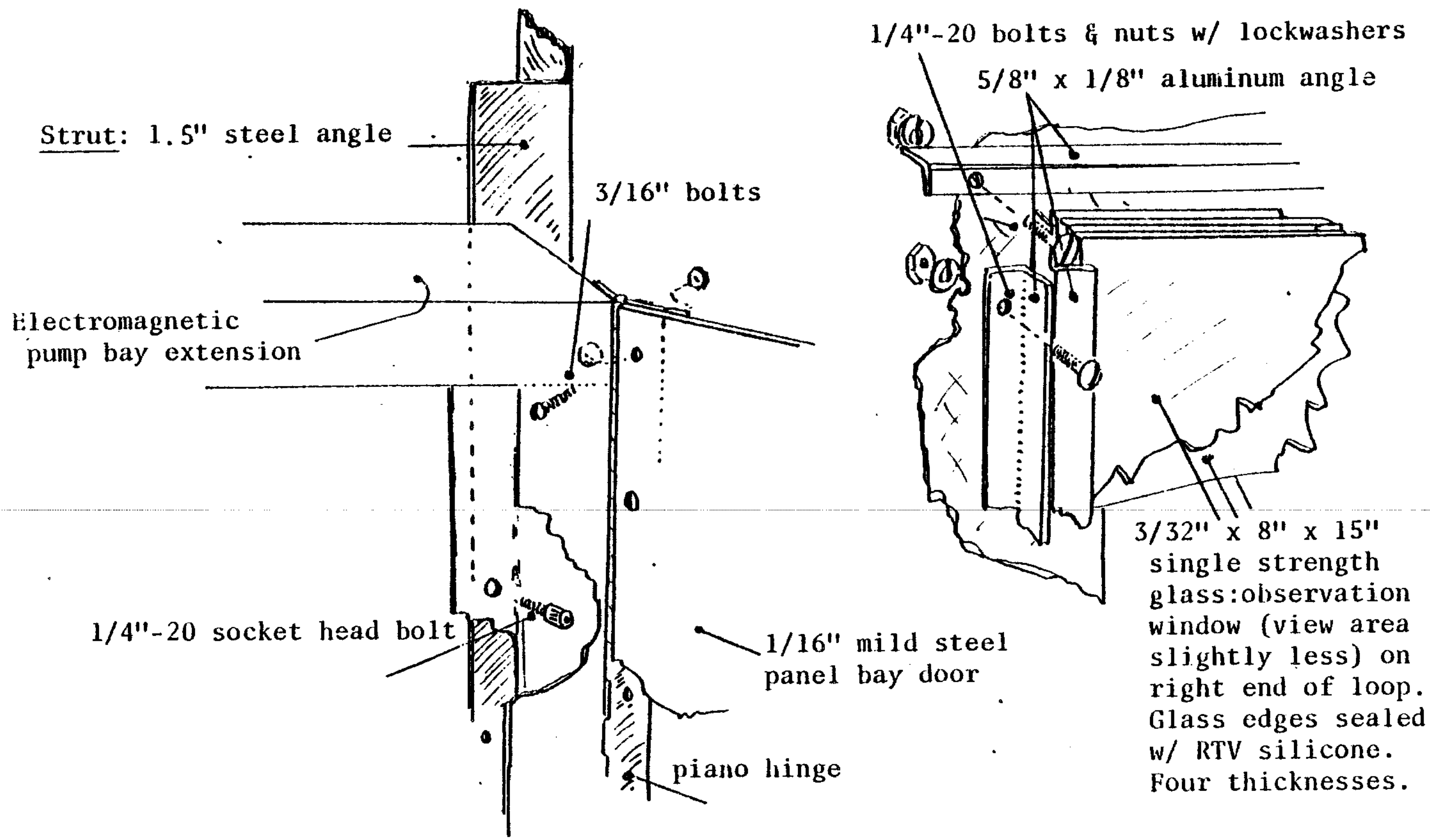


ENCLOSURE FRAME AND STRUT INFORMATION

Panels painted with Rustoleum epoxy, chemical and heat resistant, paint. Primer is 9373. Cover is aqua blue 9323. [2-22,38], [1-112], [2-8,34]

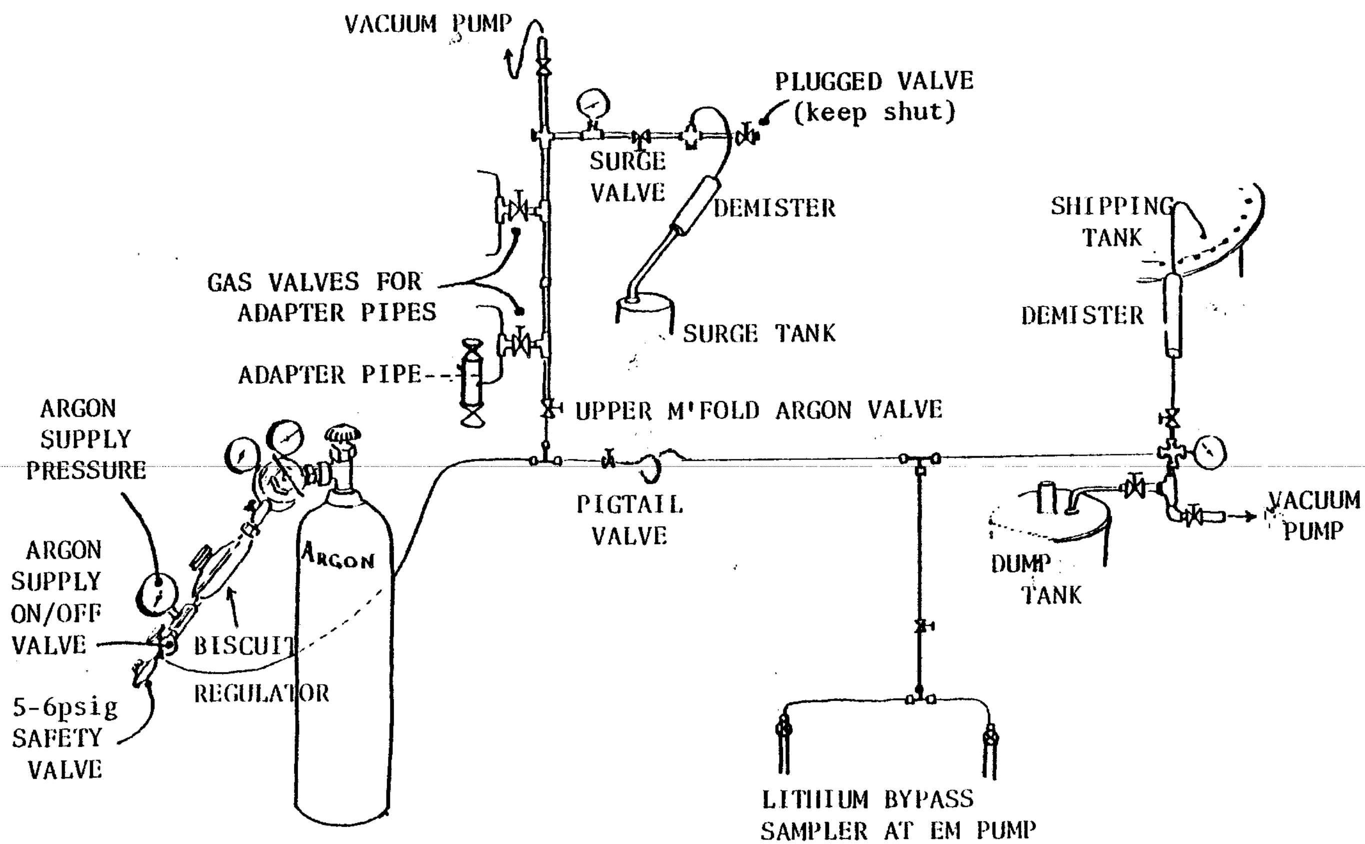


ENCLOSURE PANEL SIZE INFORMATION

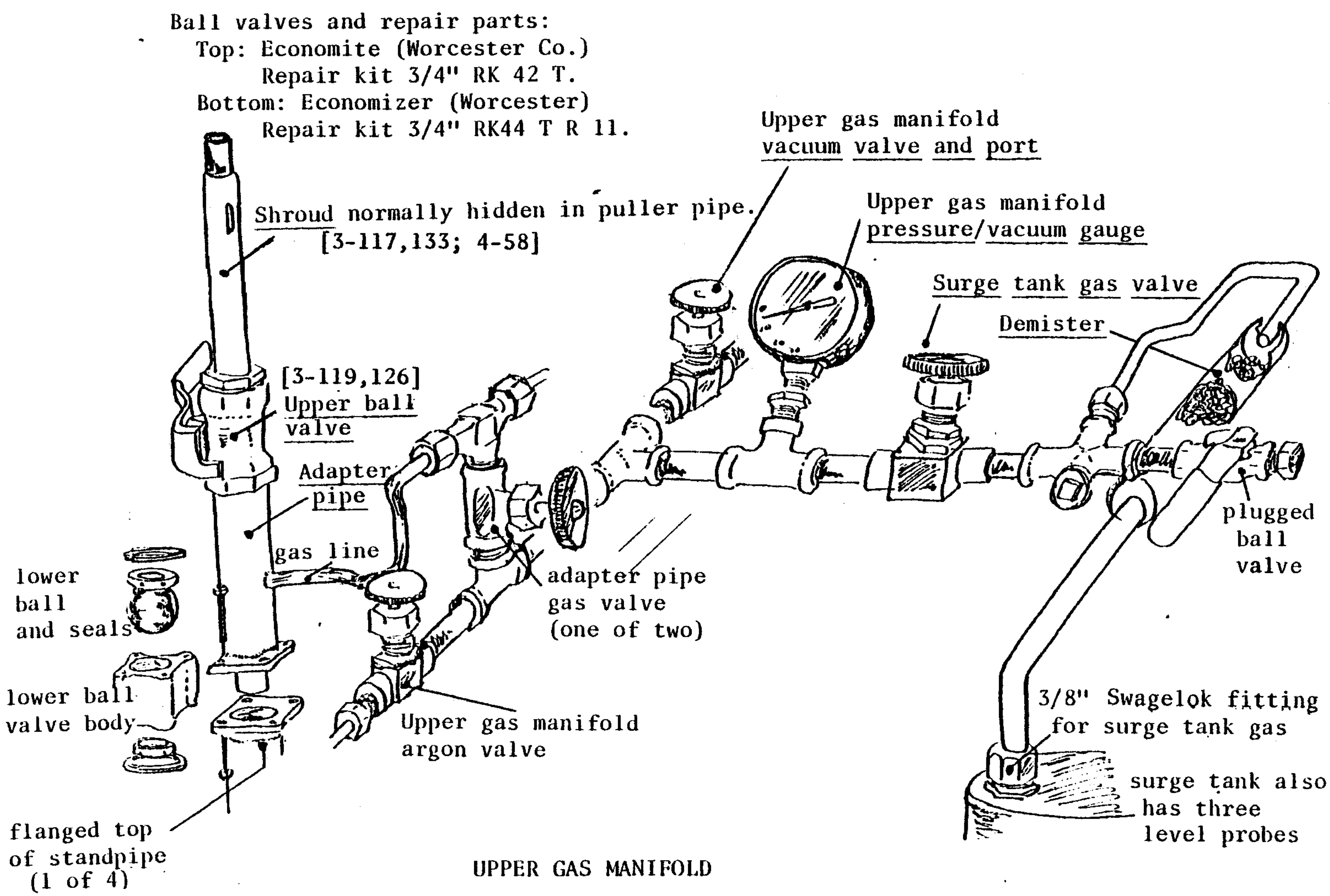


PUMP BAY DOOR AND RIGHT END OBSERVATION WINDOW DETAILS

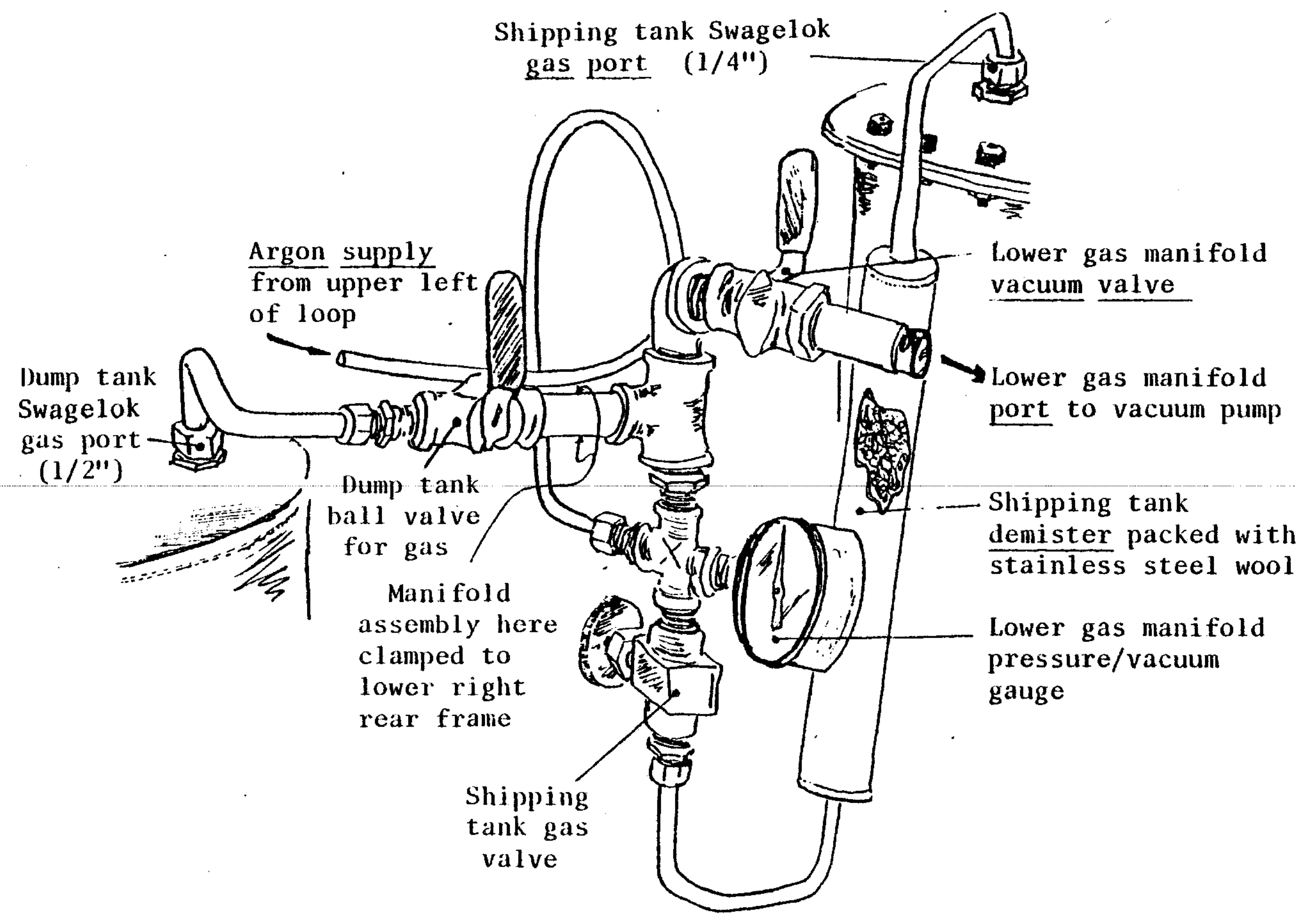
APPENDIX D. GAS SYSTEM (ARGON AND VACUUM)



COVER GAS (ARGON) AND VACUUM SYSTEM



UPPER GAS MANIFOLD



LOWER (DUMP TANK) GAS MANIFOLD

APPENDIX E. ELECTRICAL AND HEATING SUMMARY

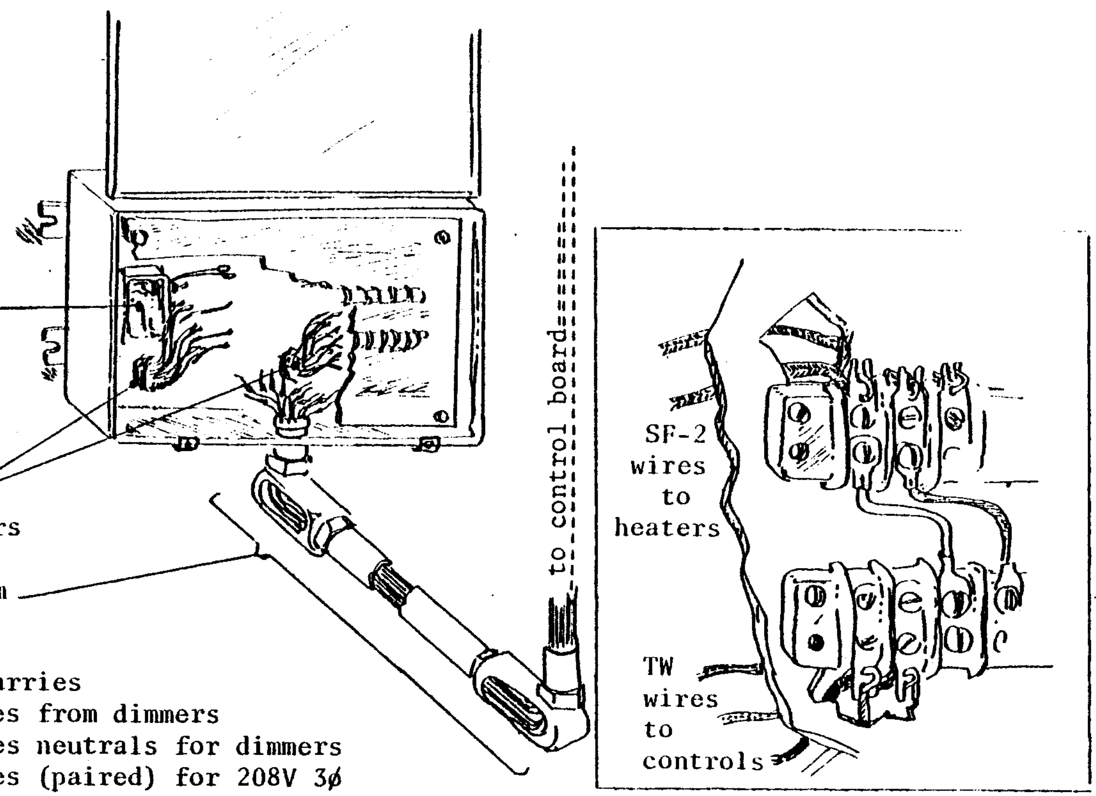
ELECTRICAL POWER SUPPLY AND DISTRIBUTION

Electromagnetic pump	208V heaters	Trace heaters	Radiator blower
Panel, 1401W ERB: 480V, single phase, 30 amperes	Breaker #33 1408 hallway: 208V, three phase, 30 amperes/phase	Breakers #21,27 1408 hallway: 208V, three phase, 30 amperes/phase	Breaker #39 1408 hallway: 208V, 3 phase, 30amps/phase
via overhead conduit 1408(west end)	via wall box & overhead flex conduit, 1408(north side)	via overhead flexible conduit, 1408 (west end)	via wall strip 1408(west)
fuse 30 ampere, in breaker box on control unit	fuse 30/35 ampere,in heater control panel	fuse 20 ampere,in heater control panel	fuse:
relay in control unit	relay in heater control	relays in heater control	contactor in wall box
variable transformer: 15 kVolt-amps Capacitor: .5 farads	variable transformers: 1.6,3.,6. kVolt-amps SCR switches: 3., 5 Kwatts Fuses: 10-20 amps	SCR dimmer switches: .6 kwatts each Fuses: 1-5 amps	single speed
via floor conduit	via floor conduit	via floor conduit	via wall strip
pump primary coils	heater terminal box	heater terminal box	blower:2 HP continuous duty
pump secondary/cell	208 volt heaters	120 volt trace heaters	

Selector switches(6) 2P2T-C off for 208V circuits

Conduits(2) to loop heaters

Conduit(1) from control panel



Size 1-1/2",carries
- 20 #14TW wires from dimmers
- 10 #14TW wires neutrals for dimmers
- 12 #12TW wires (paired) for 208V 3ϕ
- 3 #12TW wires (spares)

Detail of terminal barrier strips and connections through masonite

Connection of conduit to terminal box and control panel with condulets. Limited movement of control panel and conduit.

HEATER POWER CONNECTIONS BETWEEN CONTROL PANEL AND LOOP [1-51ff]

HEATER SUMMARY [2-114]

Number	Heater	Ohms	Watts	Length*
A-F	Main (Clamshells)(208volts)	33Ω,	1730W,	18"
10	Lower Manifold	23Ω	625W	102
11-14	Upstream of meters			
	(rear 11, midfront 13)	77Ω	190W	31
	(front 14, midrear 12)	58Ω	250W	41
21-24	Downstream of meters	58Ω	250W	41
25-30	Isothermal Oven			
	Inside(right) top 25;27,29	23Ω	625W	23-3/4***
	Outside(left) top 26;28,30	23Ω	625W	23-3/4***
68	Surge Tank	17Ω	710W	90?**
69	Upper Manifold	58Ω	250W	41
70	Upper M'fold & 2 rear headers	58Ω	250W	41
71	Upper M'fold & 2 front headers	58Ω	250W	41
72-74	Econ'mzr front bottom pass	23Ω	625W	102
75-77	Econ'mzr back pass	23Ω	625W	102
78-80	Econ'mzr front top pass	23Ω	625W	102
81	Radiator left U-bends†	58Ω	250W	41
82-85	Radiator, internal, top 82††	46Ω	310W	30-1/2***
86(old)	Rad. lowest internal, burned out	46Ω	310W	30-1/2***
86	Rad. external. Two in parallel ††	38Ω	375W	38***
87	Rad. right U-bend, Two parallel	150Ω	50W	6***§
88	Pump piping, left vertical	77Ω	190W	31
89	Pump piping, left horizontal	23Ω	625W	102
90	Pump piping, right horiz.&vert.	23Ω	625W	102
91	Radiator top/ economizer "hot"	46Ω	310W	51
92	Radiator bottom/ economizer "cool"	23Ω	625W	102
93	Cold trap	46Ω	310W	51
94	Dump pipe to upper valve	29Ω	500W	81
95	Dump pipe to lower valve	46Ω	310W	51
97-99	Dump tank,CCW from left side	23Ω	625W	102
X	Standpipes, 4 in parallel	46Ω	310W	51
Y	Pullers, 2 in series	25Ω	576W	1 x 48†††
---	Pump cell served by drop cord	25Ω	576W	1 x 48†††
---	Shipping tank, three heaters	23Ω	625W	102
---	Ship/Dump transfer tube, 2 heaters	25Ω	576W	1 x 48†††
---	Sampler heaters	100Ω	144W	.5x 24†††

*Manufacturer's watt rating at 120V. Estimated Ohms. Heated Length.
**Too much power for dimmer at 120V. §Limited to 120 Volts.
***Strip Heater.
†Limited use of 208V.
††Usually run on 208 V circuits.
†††Tape Heaters; 120 V maximum.

TRACE HEATERS--SUGGESTED CONNECTIONS AND POWER SETTINGS

Dimmer & Setting*		Heaters	Resist.,Ohms**	Amperages	Wattages	Heated Lengths§
D41	@30 = 1.9 A	(78,79)-80	(23,23)-23	(.95,.95)-1.9	(21,21)-83	(2.6,2.6)-2.6 m
D42	@30 = 1.9 A	(75,76)-77	(23,23)-23	(.95,.95)-1.9	(21,21)-83	(2.6,2.6)-2.6 m
D43	@30 = 1.9 A	(72,73)-74	(23,23)-23	(.95,.95)-1.9	(21,21)-83	(2.6,2.6)-2.6 m
D44	@20 = 1.25A	11,12	77,58	.54,.71	22,29	.39,.52 m
D45	@35 = 2.2 A	Pump cell	25	2.2	120	Pump cell
D46	@23 = 1.45A	13,14	77,58	.63,.82	30,39	.39,.52 m
D47	@32 = 2.0 A	68	17	2.0	68	Surge Tank
D48	@34 = 2.15A	70,71	46,46	1.1,1.1	56,56	.65,.65 m
D49	@28 = 1.75A	21,22	58,58	.82,.82	39,39	.52,.52 m
D50	@28 = 1.75A	23,24	58,58	.82,.82	39,39	.52,.52 m
D51	@50 = 3.1 A	25,28	32,32	1.5,1.5	72,72	Oven, top
D52	@50 = 3.1 A	26,29	32,32	1.5,1.5	72,72	Oven, middle
D53	@60 = 3.75A	27,30	32,32	1.9,1.9	115,115	Oven, bottom
D54						
D55	@52 = 3.25A	98	23	3.25	250	Dump Tank
D56	@36 = 2.25A	93,(92-94)	46,(23-29)	1.2,(1.,1.)	66,(25,32)	.65†,(1.3,1.0)m
D57	@22 = 1.4 A	10	23	1.4	45	Lower manifold††
D58	@16 = 1.0 A	91	46	1.0	46	.65m
D59	@26 = 1.6 A	89-90	23-23	1.6,1.6	59,59	1.3,1.3 m
D60	@ 7 = .45A	88-95	77-58	.45,.45	16,12	.39,.52 m

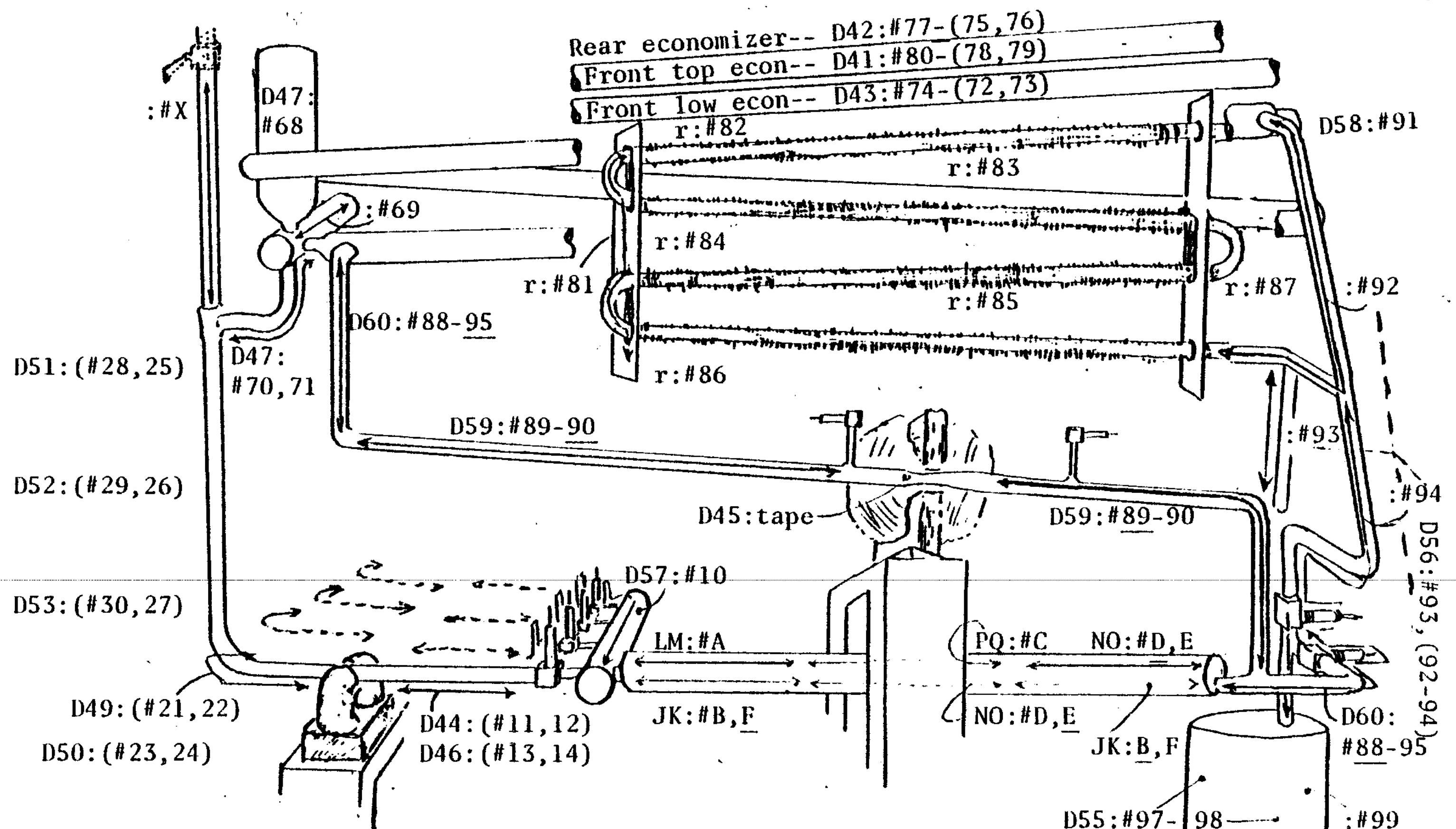
* Ammeter reading is 80 units for full scale current of 5 amperes

** Resistances:estimates from manufacturer's maximum wattage rating

§ Heated Length is one half physical length since heaters are doubled on each pipe except for heaters 72-80 which are on economizer and are not bent double.

† Cold trap; not insulated

†† Includes the four flow control valves



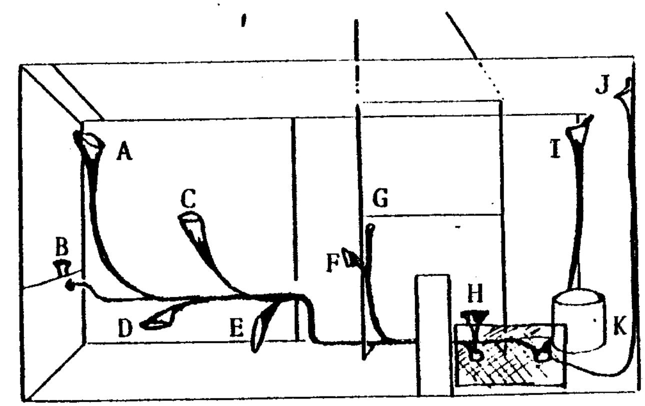
Number or letter before : is control circuit
If letter r is before : radiator(variable)wiring
If no letter or number, heater not connected
Number or letter after : is heater
Underlined heater is remote from location labeled
Note that control circuit NO & PQ are from same source

PICTORIAL LOCATION OF HEATERS WITH ASSOCIATED CONTROL CIRCUITS

APPENDIX F. THERMOCOUPLE SUMMARY

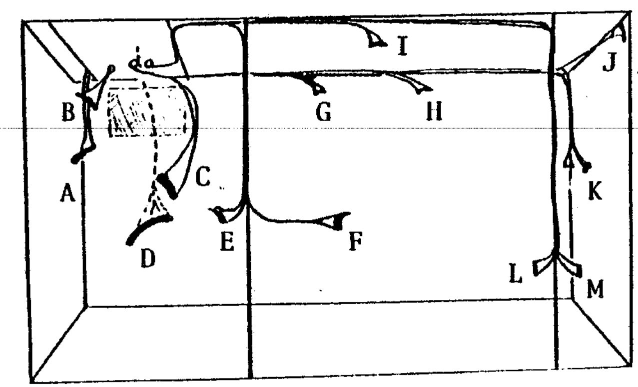
Heater wires all enter from terminal box at lower right front of loop, through two short conduits. Bundles serve these approx. parts:

A. Economizer, surge, manifold
B. Left side isothermal oven (caution: wires thru panel)
C. Economizer, EM pump pipe.
D. EM meter pipes.
E. Manifold, valve pipes.
F. Lower manifold.
G. Radiator.
H. Main heater.
I. Economizer & radiator.
J. Economizer & right end.
K. Dump tank & right end.



Thermocouple extension wires all enter at upper left back of loop. Note that TC and heater wires generally are kept apart, TC extensions to top or front, heater wire to bottom or back of enclosure. [2-86]

A. Isothermal & freeze pipes.
B. Economizer, surge, and upper manifold.
C. Meter pipes, valves.
D. Meter leads (not TCs).
E. Manifold, EM pump pipes.
F. Main heater, EM pipes.
G,H. Economizer and radiator.
I. Economizer.
J. Economizer and right end.
K. Dump and right end pipes.
L. Main heater and EM pipe.
M. Dump tank.



HEATER AND THERMOCOUPLE WIRING PATHS INSIDE LOOP ENCLOSURE

LIST OF THERMOCOUPLES--CONNECTIONS IN BOX

TC box (Row,Col)	Label	Position on Loop-------------[3-38ff]
		Note: position of thermocouple bead is stated connection is made 2-3" away.
(1, 1)	1	Pump cell: rear side, 1/2" downstream from electrodes
(1, 2)	2	Pump cell: front side,1/2" downstream from electrodes
(2, 1)	3	Pump cell: top, 6" upstream from electrodes
(2, 2)	4	Pump piping: right horiz. pipe, 3" upstream from elbow
(3, 1)	5	Pump area: usually used on lithium sampler
(3, 2)	6	Pump area: usually used on a sampler bypass valve
(4, 1)	85	Lower dump pipe, between main heater inlet and dump valve
(4, 2)	86	Pump piping: right horiz. pipe, 2" downstream from bypass port
(4, 3)	87	Pump piping: right vertical pipe,9" downstream from elbow
(4, 4)	88	Pump piping: left vertical pipe, 8" below economizer
(4, 5)	89	Pump piping; left horiz. pipe, 1" upstream from bypass port
(1, 3)	15	Main heater, outlet (left end)
(2, 3)	17	Main heater, outlet (left end)
(3, 3)	19	Lower lithium manifold, front end top
(1, 4)	16	Lower lithium manifold, middle top
(2, 4)	18	Lower lithium manifold, rear
(3, 4)	20	Lower lithium manifold, rear (#1) valve block, at bottom

*****A type J (iron-constantan) thermocouple is directly connected to the main heater controller from a thermal well in the center of the lower lithium manifold
A type K thermocouple similar to the thermocouples noted here is directly connected to the main heater overtemperature switch from the main heater outlet (left end)

(1, 5)	95	Surge tank, upper left side (5" down from top)
(1, 6)	96	Surge tank, middle right side (8" down from top)

LIST OF THERMOCOUPLES--CONNNECTIONS IN BOX (CONTINUED)

TC box (Row,Col)	Label	Position on loop-------------------------
(2, 5)	97	Upper lithium manifold, middle bottom, points to right
(2, 6)	98	Upper lithium manifold, front top
(3, 5)	75	Top of loop, usually used for puller pipe
(3, 6)	76	Top of loop, usually used for puller pipe
(5, 1)	75	Economizer, front upper pass. Over pump
(5, 2)	76	Economizer, right end bend, toward rear
(5, 3)	77	Economizer, front upper pass, 6" upstream from end connecting to radiator
(5, 4)	78	Economizer, front lower pass, 14" from left end (bead at 6" from left?)
(5, 5)	79	Economizer, front lower pass, bead approximately 4'6" from left(over pump)
(5, 6)	80	Economizer, front upper pass, 6" from left bend (on the straight section)
(6, 3)	P	Economizer, rear pass, approximately 20" from right bend, on straight
(6, 4)	S	Economizer, rear pass, approximately 30" from right bend, on straight
(6, 5)	Z	Economizer, rear pass, approximately 30" from left bend, on straight
(4, 6)	77	Upper dump pipe, 7" below tee from radiator to economizer
(6, 1)	G	Main heater inlet
(6, 2)	K	Upper dump pipe, middle of horizontal section(not in flow path)
(7, 1)	I	Radiator-to-economizer return piping, vertical section, middle
(7, 2)	L	Economizer-to-radiator supply piping, 4" from front
(10, 1)	hi	Upper dump valve, on valve tube
(10, 2)	lo	Lower dump valve, on valve tube

LIST OF THERMOCOUPLES--CONNECTIONS IN BOX (CONTINUED)

TC box (Row,Col)	Label	Position on loop
(8, 1)	J	Dump tank, front middle
(8, 2)	M	Dump tank, right bottom
(9, 1)	N	Shipping tank, front top
(9, 2)	O	Shipping tank, front bottom
(7, 3)	Q	Cold trap, 6-1/2" down from tee on radiator outlet elbow
(8, 3)	R	Cold trap, 10-1/2" down
(9, 3)	Q	Cold trap, 14-1/2" down
(10, 3)	R	Cold trap, 18-1/2" down
(7, 4)	T	Radiator, first (upper) pass right half
(7, 5)	2	Radiator, first pass left half
(7, 6)	8	Radiator top left U-bend
(8, 4)	U	Radiator, second pass left half
(8, 5)	5	Radiator, second pass right half
(8, 6)	9	Radiator right U-bend (lower side)
(9, 4)	V	Radiator, third pass right half
(9, 5)	6	Radiator, third pass, left half
(9, 6)	15	Radiator bottom left U-bend
(10, 4)	W	Radiator, fourth (bottom) pass left half
(10, 5)	7	Radiator, fourth pass right half
(10, 6)	16	Radiator-to-economizer return piping, horizontal pipe

LIST OF THERMOCOUPLES--CONNECTIONS IN BOX (CONTINUED)

TC box (Row,Col)	Label	Position on Loop---------------------------
(1,7-10)	G,L,Q,V	Isothermal test zone, top. 5" down from tee; 16th coupon.G=rear,V=front*
(2,7-10)	H,M,R,W	Isothermal test zone, 9" down from tee; 12th coupon. H=rear, W=front*
(3,7-10)	I,N,S,Z	Isothermal test zone, 13" down from tee; 8th coupon. I=rear, Z=front*
(4,7-10)	J,O,T,31	Isothermal test zone, 17" down from tee; 4th coupon. J=rear,31=front*
(5,7-10)	K,P,U,32	Isothermal test zone, 21" down from tee; inlet. K = rear, 32 =front*

* Rear (column 7) test section is highest velocity, designated first section.
Second test section (column 8) is lower middle velocity.
Third test section (column 9) is lowest velocity.
Front (column 10) test section is higher middle velocity, designated fourth test section.
Oven extends from tee (4" above stringer) down 24" (3" below stringer).

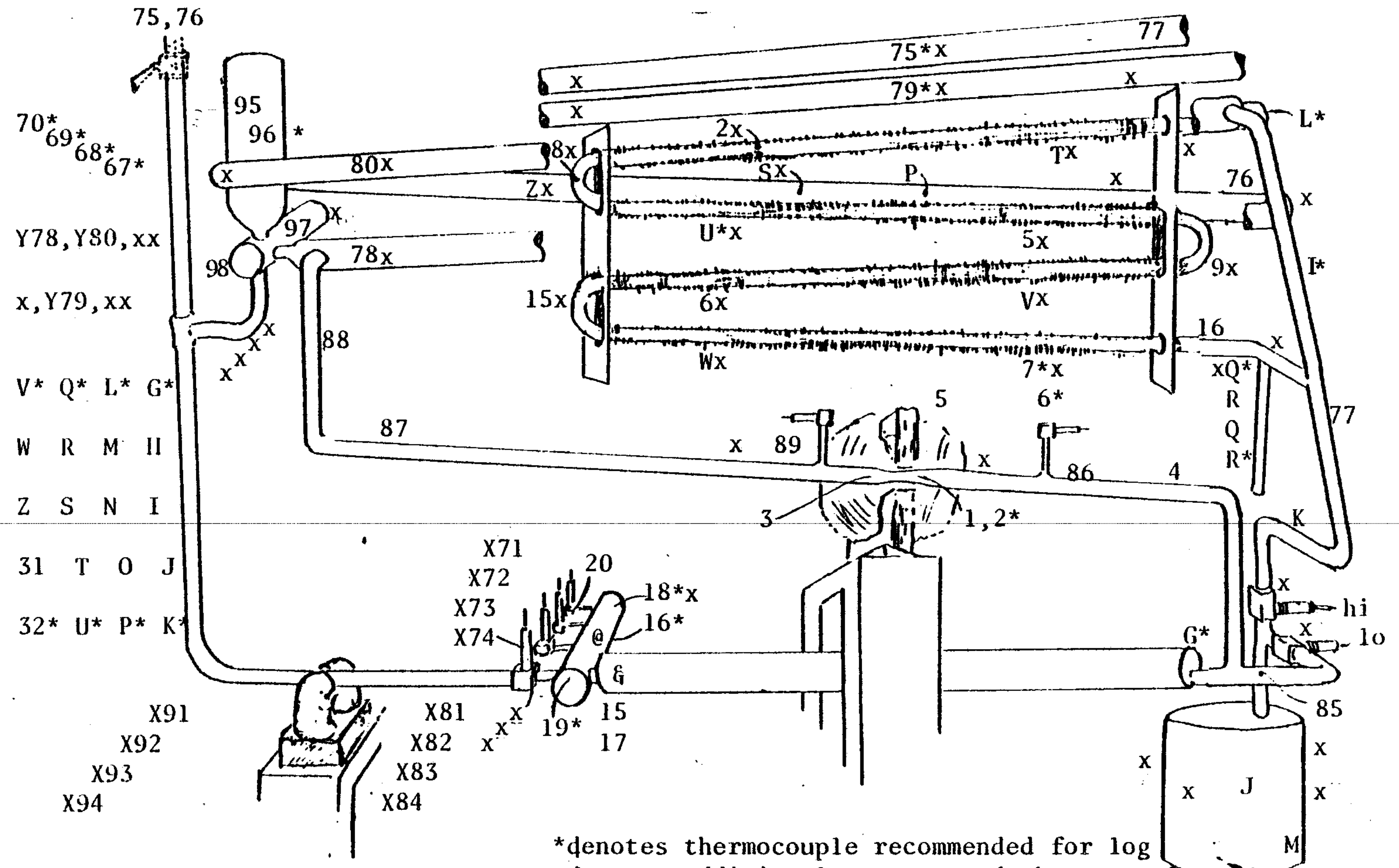
(6,7-10)	X91-X94	Test section piping between meter and isothermal test zone.X91=rear.
(7,7-10)	X81-X84	Test section piping between valve and meter. X81=rear, X84=front.
(8,7-10)	X71-X74	Test section flow control valve, located on valve tube. X71=rear.
(9,7-10)	67 - 70	Freeze standpipes, upper thermocouple**67 = rear, 70 = front standpipe.
(10, 8)	Y78	Front (fourth) freeze standpipe, middle thermocouple.**
(10, 9)	Y79	Third standpipe, bottom thermocouple.**
(10, 10)	Y80	Third standpipe, middle thermocouple.**
		**Standpipe thermocouples upper, mid, bottom:approx. 4,9,15" below flange. 17,12,6" above tee.
(6, 6)		Not used
(10, 7)		Not used

(direct connection):Main heater outlet,type K:to main heater overtemperature switch
(direct connection):Lower lithium manifold central thermal well,type J:to main heat control

LIST OF THERMOCOUPLES--SUGGESTED FOR RECORDERS

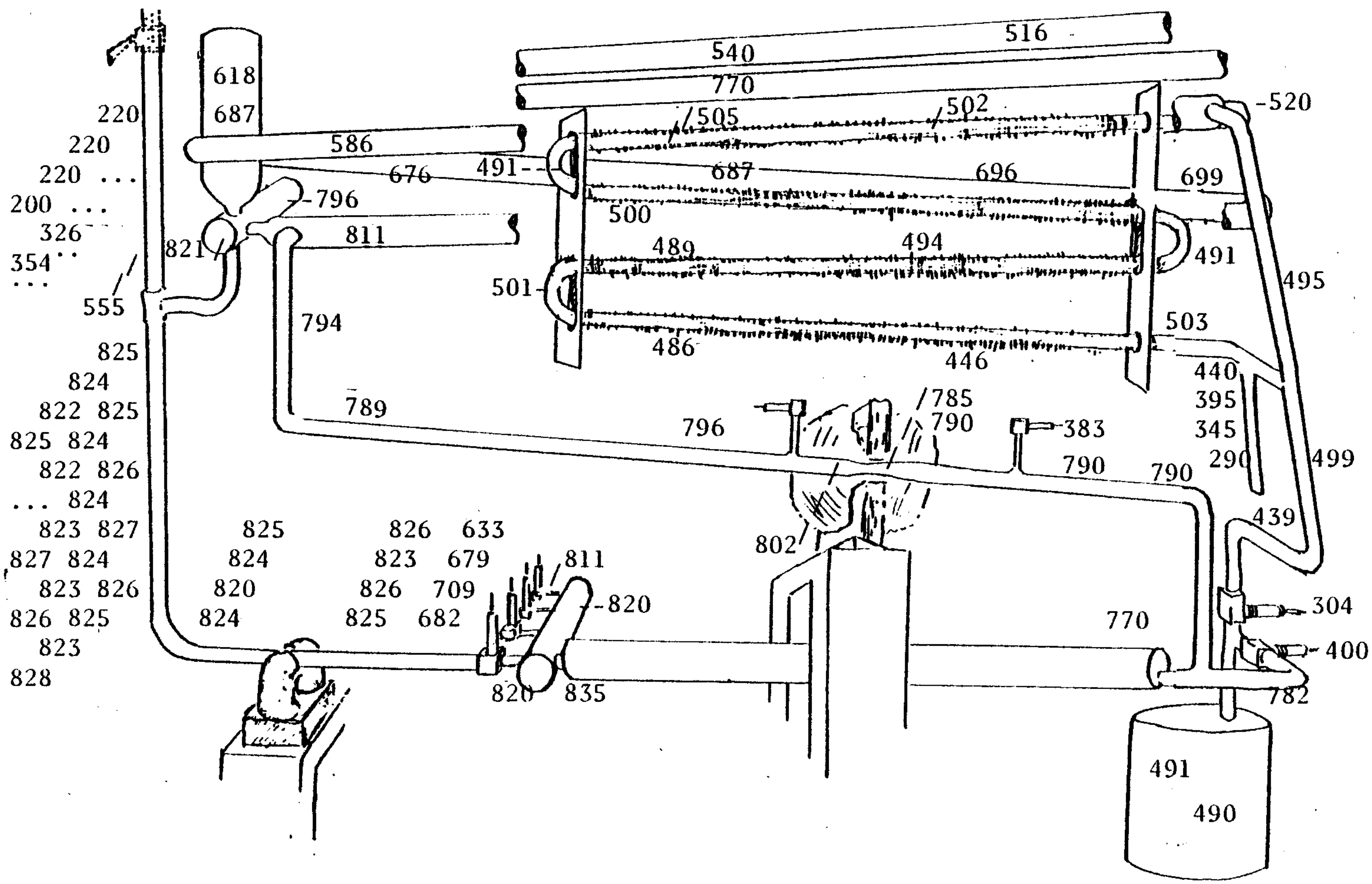
Recorder &Channel	TC box (Row,Col)	Label	Position on loop--------------------------------
A1-A4	(9,7-10)	67-70	Freeze standpipes, upper thermocouple. 67=rear.
A5	(5, 1)	75	Economizer, front upper pass middle (over pump)
A6	(6, 4)	S	Economizer, rear pass, middle (approx. 50" from right bend)
A7	(5, 5)	79	Economizer, front lower pass middle (over pump)
A8	(6, 1)	G	Main heater inlet
A9	(1, 2)	2	Pump cell: front side, 1/2" downstream from electrodes
A10	(1, 6)	96	Surge tank, middle right side
A11	(10, 1)	hi	Upper dump valve, on valve tube
A12	(10, 2)	lo	Lower dump valve, on valve tube
B5	(7, 2)	L	Economizer-to-radiator supply piping, 4" from front
B6	(10, 5)	U	Radiator, second (higher) pass left half
B7	(10, 5)	7	Radiator, fourth (bottom) pass right half
B8	(7, 3)	Q	Cold trap, 6-1/2" down from tee on radiator outlet elbow
B9	(10, 3)	R	Cold trap, 18-1/2" down from tee
B12	(7, 1)	I	Radiator-to-economizer return piping, vertical section,middle.
C1-C4	(1,7-10)	G,L,Q,V	Isothermal test zone, top. 5" down from tee. 16th coupon.G=rear.
C5-C8	(5,7-10)	K,P,U,32	Isothermal test zone, bottom. 21" down from tee. Inlet. K=rear.
C9	(3, 2)	6	Pump area; usually used on a sampler bypass valve.
C10	(3, 3)	19	Lower lithium manifold, front end top.
C11	(1, 4)	16	Lower lithium manifold, middle top.
C12	(2, 4)	18	Lower lithium manifold, rear.

The following thermocouples are directly connected without plugs:
There is a type J (iron-constantan) thermocouple in a well in center of lower manifold.
There is a type K (chromel-alumel) thermocouple on the outlet of the main heater.
These are connected, respectively, to main heater controller and main overtemp.switch.

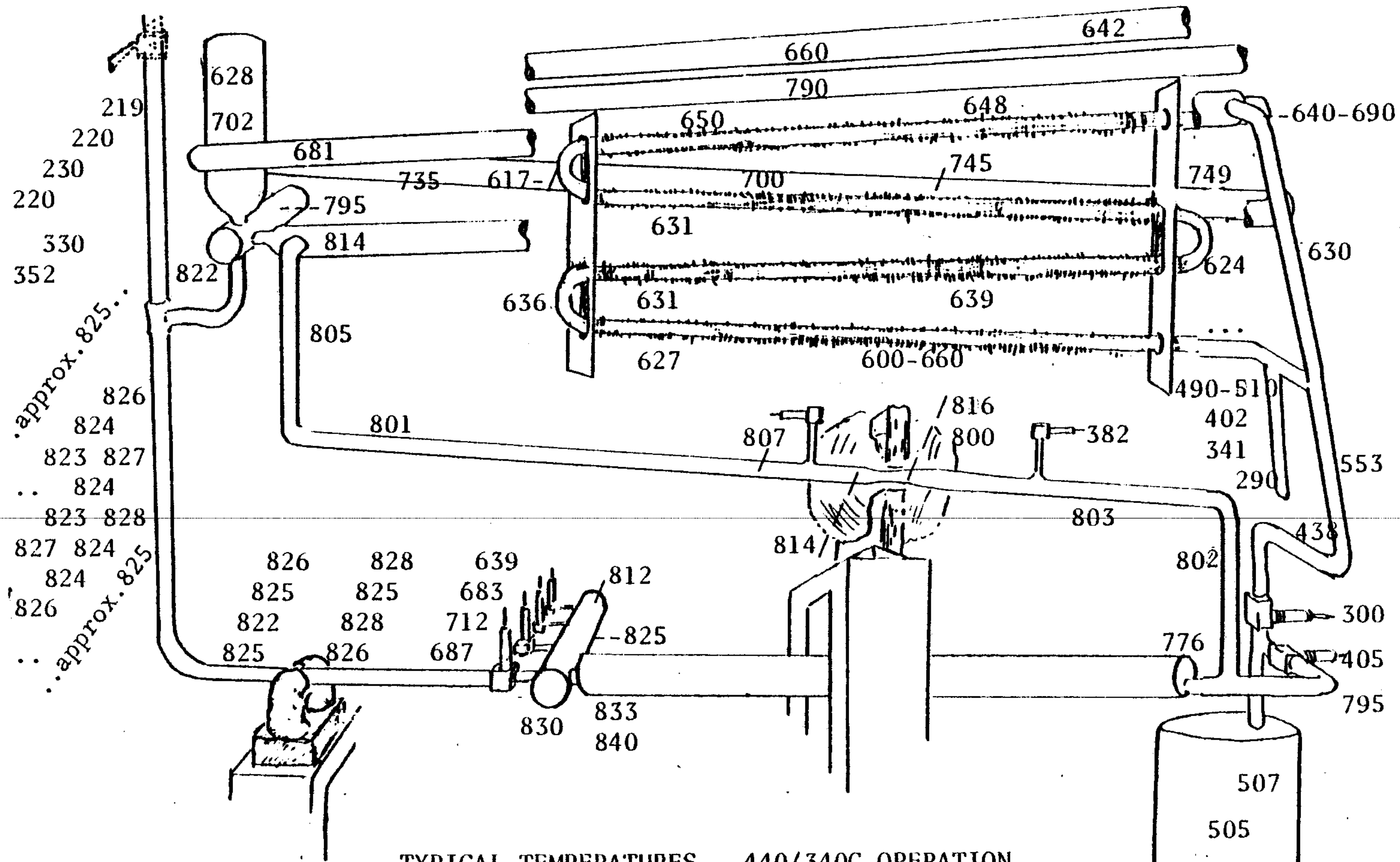


*denotes thermocouple recommended for log
xdenotes additional unconnected thermocouple
@denotes type J thermocouple for temperature control
&denotes direct-connected thermocouple for overheat safety

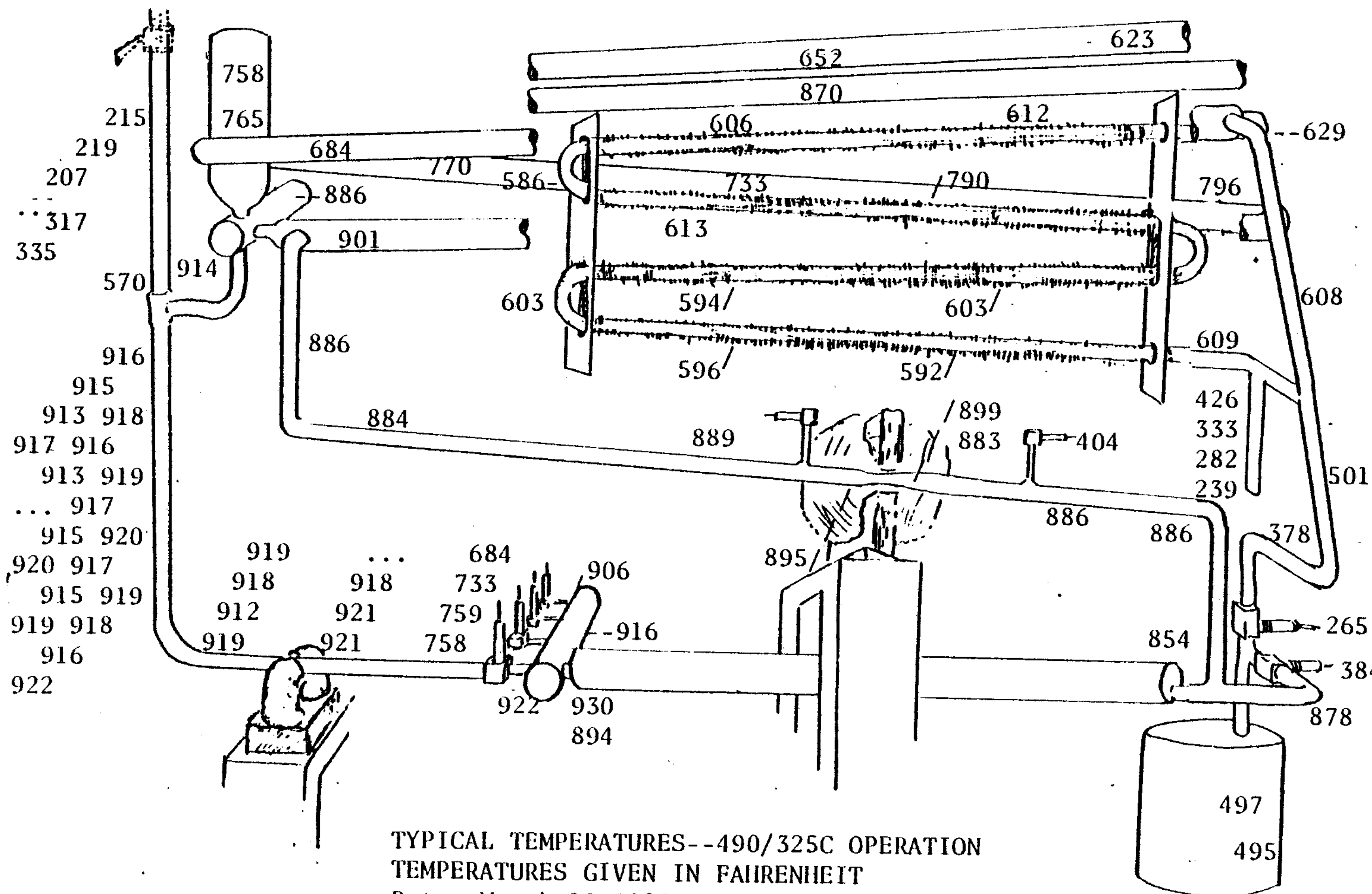
PICTORIAL LOCATION OF THERMOCOUPLES ON LITHIUM LOOP



TYPICAL TEMPERATURES--440/255C OPERATION
TEMPERATURES GIVEN IN FAHRENHEIT
Date: January 20, 1979



TYPICAL TEMPERATURES --440/340C OPERATION
TEMPERATURES GIVEN IN FAHRENHEIT
Date: July 2, 1979



TYPICAL TEMPERATURES--490/325C OPERATION
TEMPERATURES GIVEN IN FAHRENHEIT
Date: March 19,1980

APPENDIX G. COMPONENT VOLUME AND FILLING INFORMATION

COMPONENT VOLUMES AND FILLING INFORMATION

Component	L(ft)	ID(in)	Nom. Size	Vol. (in^3)	Cum.Vol.	Dump Equv*	Remarks
Main heater	4.5	2.47	2.5" Sc 40	258			
Lower manifold	1.5	1.44	1.25 Sc 10	31			
Meter sections	14	.53	5/8 x .049	36			test section
				325	325	2.7"	will now fill
Test sections	14	.53	5/8 x .049	36			
Pump piping	9.75	.62	1/2 Sc 40	35			
Lower radiator	10	.62	1/2 Sc 40	37			
Lower right end	4.5	.62	1/2 Sc 40	17			
Upper manifold	1.5	1.44	1.25 Sc 10	31			test section &
				156	481	4.0"	manifold full
Economizer	26	1.38	1.25 Sc 40	464(3x155)	636	5.3"	--econ 1/3 full; surge filling
Upper radiator	10	.62	1/2 Sc 40	37			
Upper right end	4.75	.62	1/2 Sc 40	17			
Surge tank(2/3)	.77	4.26	4 Sc 10	132	911	7.6"	--econ 2/3 full; surge 1/3 full
Standpipes(2/3)	4.6	.62	1/2 Sc 40	17			
				667	1148	9.6"	--econ full; surge 2/3 full
Surge tank(1/3)**	.39	4.26	4 Sc 10	67			
Standpipes(1/3)	2.4	.62	1/2 Sc 40	9			
				76	1224	10.2"	loop full; overflow of stdpipes

*Equivalent level change of lithium in dump tank (120 in^3/in).

**Top of surge tank is 2" above standpipe flange.
Surge tank height taken as 14" (overall 16" including top 2" and hemispherical bottom.

APPENDIX H. SUPPORTS AND HANGERS; X-RAYS OF WELDS

SUPPORTS FOR LOOP COMPONENTS

pump cell Movement in horizontal plane very limited by shim silver electrodes. Slightly more axial than transverse freedom. Up-down movement restricted by close clearance with pump magnet poles.

dump tank Rests on ball bearings, allowing horizontal motion with connected loop piping. Fixed gas and fill tubing reduces mobility.

radiator U-bends and inlet & outlet pipes supported in slots and holes in sheet metal ends of radiator housing. These allow some axial movement against friction with the sheet metal. No front to back mobility, very little up-down mobility.

test section Very limited friction support by isothermal oven. Essentially "floating" with nearest supports at the inlet lower lithium manifold and outlet upper manifold.

meter sections Axial and vertical freedom. Transverse movement limited by meter magnet poles.

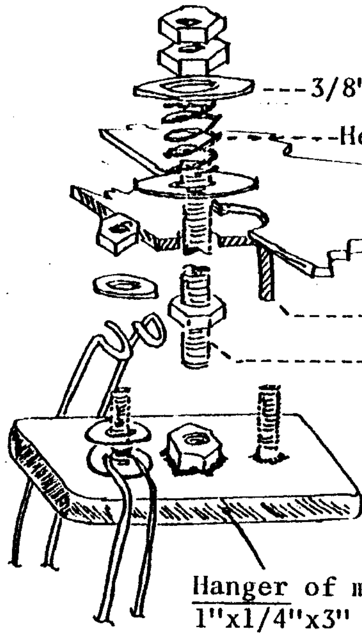
surge tank "Floating" in insulation, supported on pipe from upper lithium manifold.

freeze standpipes Fixed weakly by gas tubing from upper gas manifold. Sometimes clamped against frame.

HANGERS- - - Spring-leaded 3/8" rods from roof of loop

Component	Roof position (from left, front)	
Upper lithium manifold	(11-1/4",19-1/4"),	(11-1/4",6-3/4")
Economizer lower front section	(41.25,4.5&11.5),	(93.5,4.5&11.5),
Economizer back section	(17, 26.25),	(93.5,26.25)
Economizer upper front section	(17, 8.25),	(93.5,8.25)
Main heater sling assembly	(41.25,6&10),	(93.5,6&10)
Lower lithium manifold sling	(37.25,1.25 & 28.75)	

DETAILS OF HANGERS



---3/8"-16 nuts, large 1/2" washers

---Heavy springs

----1/16" steel panel-roof of enclosure

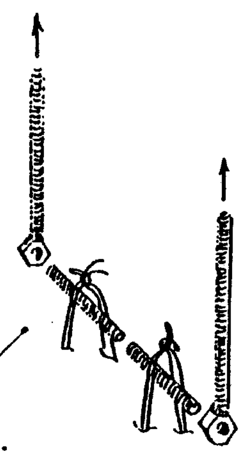
--------1-1/2" steel angle strut

-----------3/8"-16 threaded steel rod

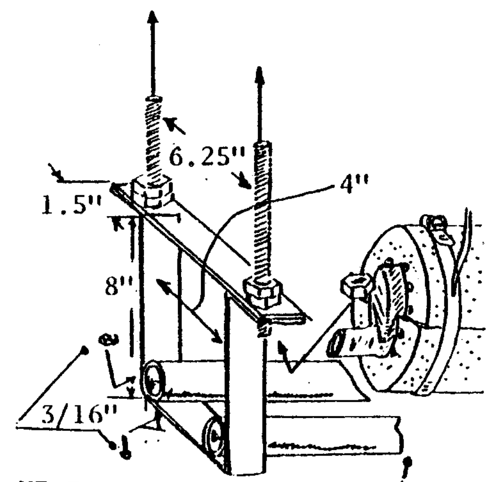
HANGER
[2-15]

wire sling of SS304
.06" wire--holds
shimmed, thermocoupled & heatered
pipe. Insulation
goes over and
around slings.
[2-15]

Hanger of mild steel.
1"x1/4"x3" long.
3/8"-16 nut welded
over center hole.
1/4"-20x1" studs
centered across
width and at 3/4"
from each end.



MANIFOLD HANGER:
3/8" mild steel rods.
3/8"-16 threads on ends
of 29-1/2" horizontal
and on top end of 4ft verticals.
3/8"-16 nuts welded on low end
of verticals. Wire slings as
described to left. [2- 59]



HEATER HANGERS [2-122]
1.5" wide, two thicknesses
stainless steel 304 #16
straps; 3/8"-16 rods,
1" stainless tubes 54" long.

X-RAY INFORMATION ON WELDS [2-89]

Selected welds are listed (all welds were x-rayed) with identifying numbers which appear on the x-rays. X-rays by Robert Edwards.

pump piping

right bottom tee to heater and dump tank. 2
right elbow 12
right sampler port. 14
pump cell ("2" is to front, "1" to rear). 21
left sampler port .15*
left bottom elbow .16
left top elbow from economizer. 17**

lower lithium manifold and valves

manifold-to-valves, front to back 1-4
heater-to-manifold. 20

test section, headers and upper lithium manifold

test section (bottom) stringer stop 5-8
test section tee adapters front to back 9-12
manifold to economizer. 18
manifold to surge tank. 19***

radiator and right end piping

lower left U-bend top to bottom 1-3
upper left U-bend bottom to top 4-6
right U-bend. 7,13
heater inlet. 1****
heater inlet tee. 2
elbow near lower dump valve 3
tee between dump valves 4
elbow near upper dump valve 5**
tee between economizer, radiator, and upper dump valve. 6
tee over cold trap. 7
radiator outlet (bottom) pipe 8
radiator inlet (top) pipe 9
economizer outlet (end) to radiator 10
economizer inlet (side) from radiator 11
cold trap bottom (end). 22

*"dirty" first weld, rewelded
**slight melt-through
***defective argon purge first weld; partial penetration. Rewelded.
****three gas voids; ground out lower side and rewelded.

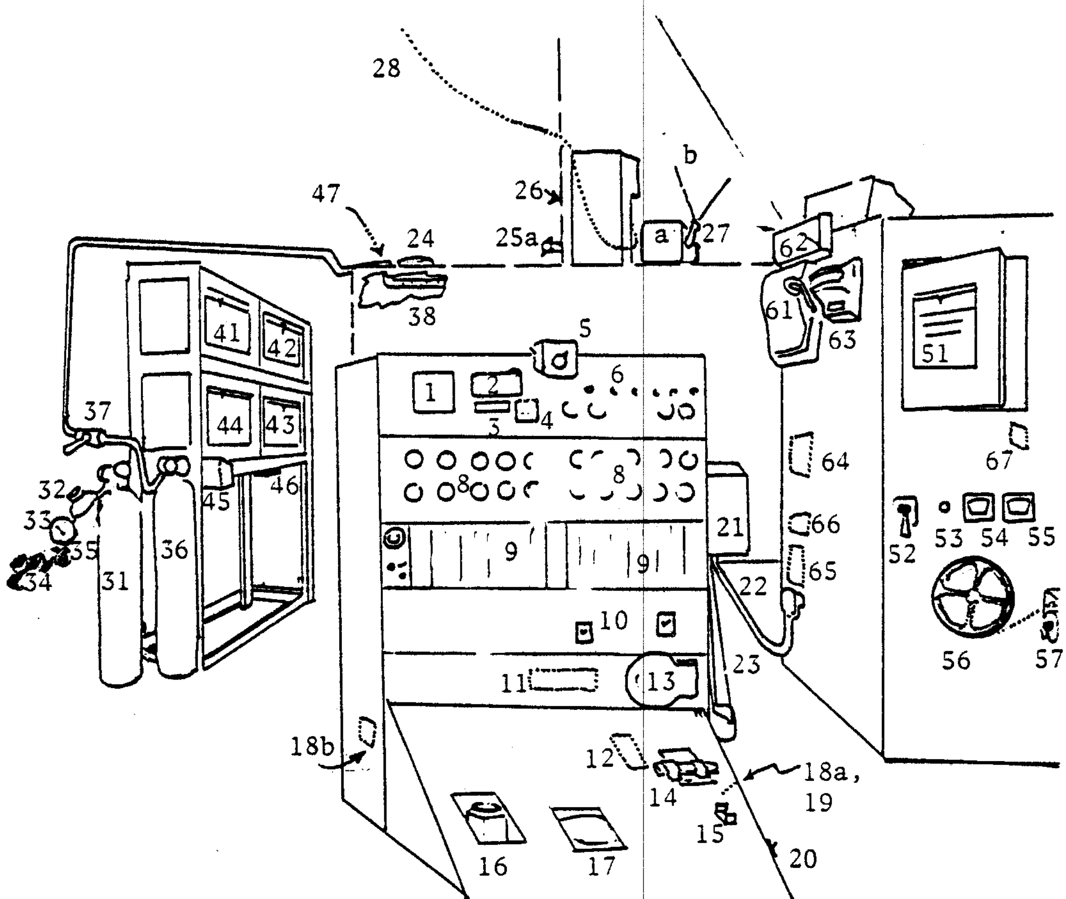
APPENDIX I. CONTROL AND SAFETY SYSTEMS

Summary

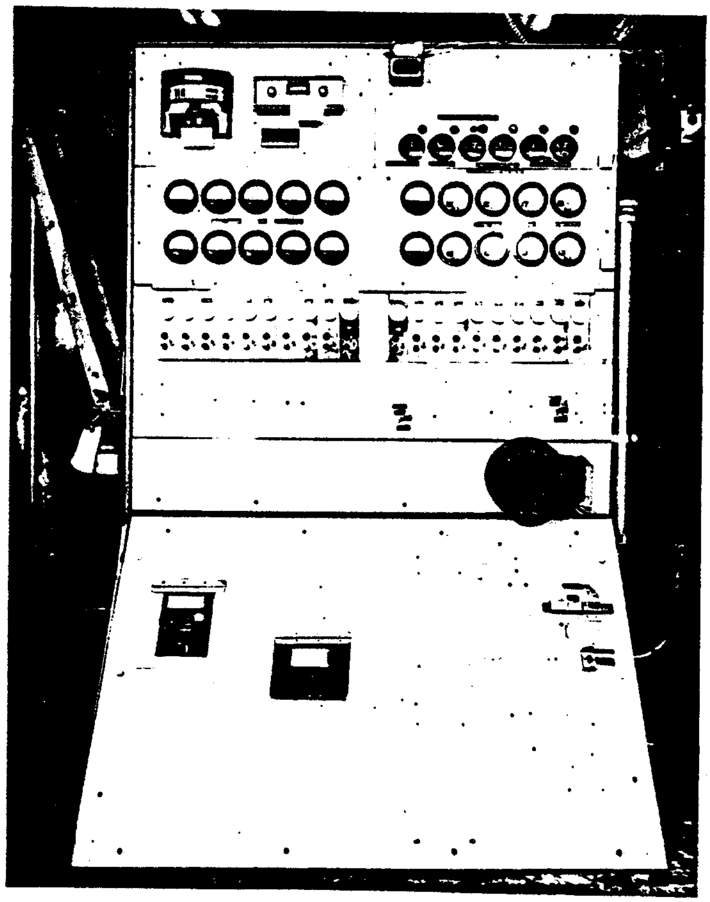
Control Board

Wiring Schematics &

Explanation of Alarm System



CONTROL, SAFETY AND MONITORING EQUIPMENT



LITHIUM LOOP HEATER CONTROL BOARD

CONTROL, SAFETY, AND MONITORING EQUIPMENT

ON HEATER CONTROL BOARD

1. Setpoint/comparator monitor for type J thermocouple in lower lithium manifold well.
2. Controller "JK" with switches for: auto/manual, % power, PID settings.Circuit "JK".
3. Digital thermocouple readout for type K thermocouples.
4. Digital temperature setpoint & controller for type K TC. (Radiator heat) Circuit "TU".
5. Radiator damper control. Variable opening and auto/manual switches.
6. Fuses(6) for 208 volt main or radiator heater load circuits JK to TU.
7. Ammeters(6) for 208 volt load circuits JK to TU.
8. Ammeters(20) for 120 volt trade heat load circuits D41 to D60.
9. Dimmer assemblies(20) for trace heat load circuits.D41 to D60.Switch,dimmer,fuse,pilot.
10. Trace heat auto/manual switches (2) for supply circuits #21 and #27.
11. Fuses(6) for trace heat supply circuits #21 and #27 (behind panel), 3 phases/circuit.
12. Fuses(3) for main heat supply circuit #33 (behind panel), 3 phase circuit.
13. Variable transformer for 208 volt loads. Circuit "LM".
14. Main heater auto/manual switch for circuits JK-PQ. (Can be rewired to include RS&TU).
15. Main heater manual-operation-enable safety spring-open switch.
16. Variable transformer for radiator heaters. Circuit "RS".
17. Variable transformer for main heaters. Circuits "NO" and "PQ".

18a. SCR power unit for controller circuit "JK" (lower right side of panel).

18b. SCR solid state relay for controller circuit "TU" (lower left inside of panel).

19. Auxiliary heater-controller auto/manual switch (lower right side of panel).
20. Pump/main heater interlock enable/override switch.

CONTROL, SAFETY, AND MONITORING EQUIPMENT (CONTINUED)

ON LOOP ENCLOSURE

21. Heater terminal box for connecting controlled power wiring to heater wires.
22. Electromagnetic pump electrical conduit (2 large wires).
23. Heater power wiring conduit (45 wires size #14 & #12).
24. Surge tank level probes (3).
25a. Smoke alarm upper photodiode (left of duct) and lamp (right of duct).
25b. Smoke alarm lower photodiode and lamp (in duct, rear inside of loop near floor).
26. Relays (2) for short-out level probes.
27a. Damper servo motor.
27b. Damper cables.
28. Loop enclosure vent lanyard. Pull to vent enclosure into exhaust duct.[5-66]

ARGON CYLINDERS

31. High purity argon cover gas for loop. Cylinder and 2-stage regulator.
32. Low pressure "biscuit" regulator for high purity loop cover gas argon.
33. Low pressure gauge for high purity loop cover gas argon.
34. Low pressure (5-6psig) safety valve for high purity loop cover gas argon.
35. Delivery valve for high purity loop cover gas argon.
36. Argon "flood" gas for enclosure in case of fire. Cylinder and 2-stage regulator.
37. Argon "flood" gas ball valve
38. Argon "flood" gas sparger (in loop enclosure at upper left end)

LITHIUM LOOP THERMOCOUPLE AND FLOWMETER RECORDERS

CONTROL, SAFETY, AND MONITORING EQUIPMENT (CONTINUED)

ON RECORDER STAND

41. Potentiometric recorder "A". Monitors 12 type K thermocouples. Recommended to monitor standpipes, surge tank and dump valves, pump cell and economizer.
42. Potentiometric recorder "B". Monitors 6 type K thermocouples. Recommended to monitor radiator and cold trap (cool zone). 0-2000F (as are "A" and "C".)
43. Potentiometric recorder "C". Monitors 12 type K thermocouples. Recommended to monitor isothermal test zone and lower lithium manifold (hot zone).
44. Potentiometric recorder for millivolt signals in 0-10 mv range. Recommended to monitor the four flowmeters on channels 1-4 and the first (high velocity section) flowmeter on channels 5-16.
45. Power supply and pilot lights for short-out level probes.
46. Selector switch for recorders. Left:"on" continuously. Center: "off" (individual recorders may be turned on). Right: "automatic" on for about two recorder cycles every two hours. "On" and "auto" affect all recorders. Also, during scram, "auto" setting causes recorders to run continuously. Normal setting is "auto". Switch is under recorder "C".
47. Thermocouple plug-in box (behind loop on upper left of enclosure). 30 phone plugs from recorders A,B,C; 100 phone jacks from thermocouples on loop.
48. (Recommended) temperature controller/safety switch to be used in series with #63 to sense main heater overtemperature. Would be available as a backup controller for main heater control or radiator heater control.

CONTROL, SAFETY, AND MONITORING EQUIPMENT (CONTINUED)

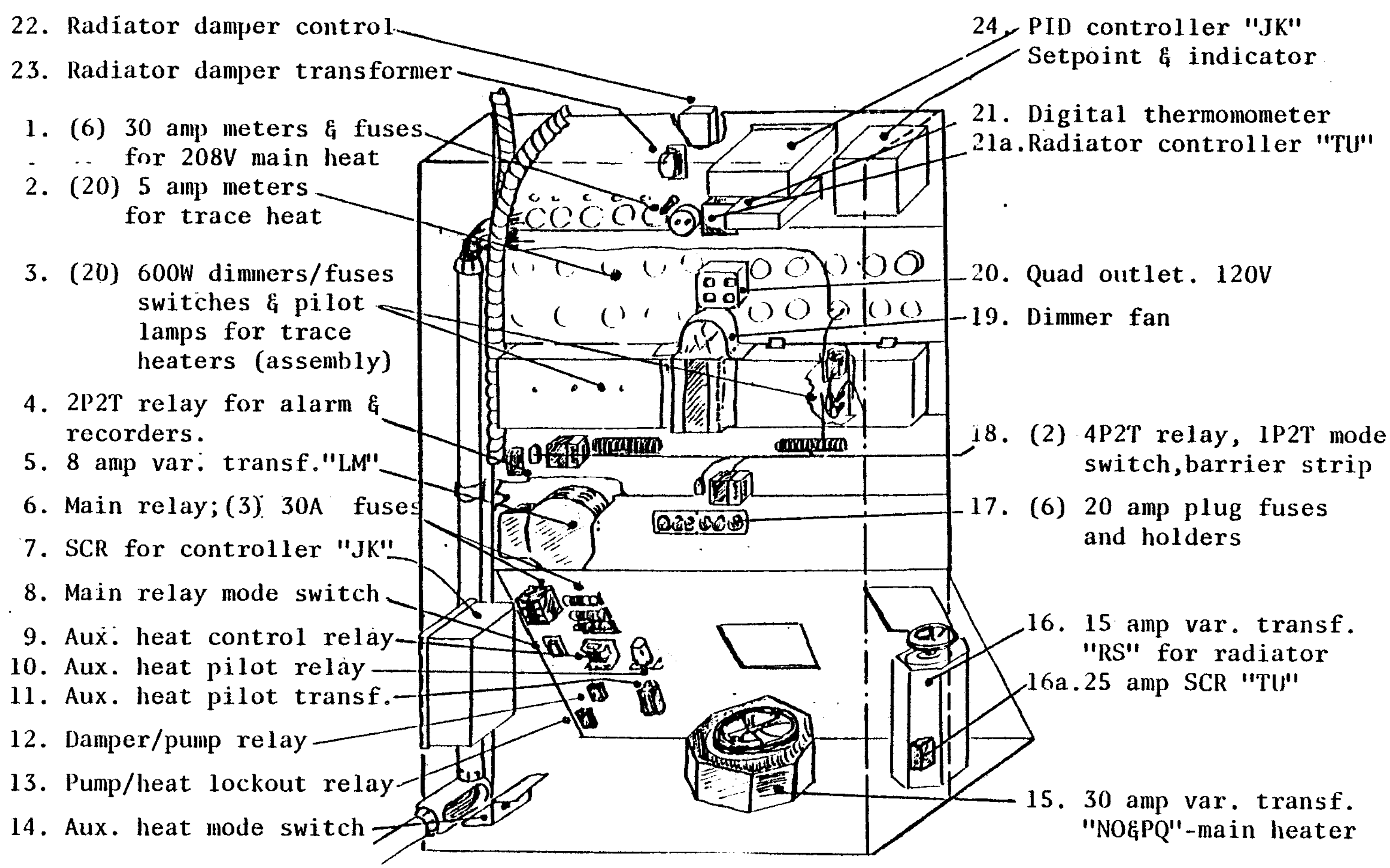
ON PUMP CONTROL PANEL: FRONT OF PANEL

51. Potentiometric level indicator for continuous level probe in surge tank. 0-50mv.
52. Electromagnetic pump start/stop switch. Pump can also be stopped by turning off circuit #16 in the hallway breaker box.
53. Electromagnetic pump pilot light.
54. Electromagnetic pump primary current meter.
55. Electromagnetic pump primary voltage meter.
56. Electromagnetic pump variable control transformer handwheel.
57. Electromagnetic pump slowdown servomotor, turns down transformer in scram. [5-59,67]

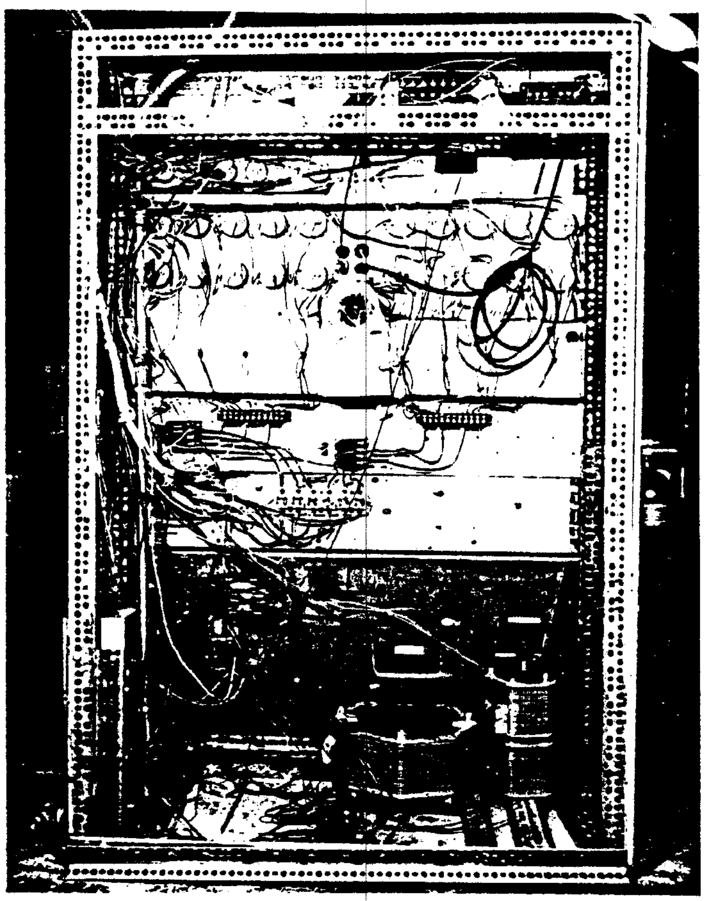
ON PUMP CONTROL PANEL:

61. Breaker- and fusebox for electromagnetic pump.
62. Dual channel smoke alarm electronics and power.
63. Capacitance-type temperature indicator and high limit switch for main heater outlet.
64. Constant current source for surge tank continuous level probe (inside panel).
65. Variable resistor adjustment for voltage to lamps used by smoke detector.
66. Latching relay for "scram" safety alarm system. Held shut electrically, this relay must be manually reset after all safety switches are closed (all conditions okay).
67. Electromagnetic pump enable relay. Held closed on circuit #16 of hallway breaker box.
68. Radiator blower switch (on wall behind pump control panel).

64-67 are inside of pump control panel. Lower smoke alarm and radiator blower are on the lower back of the loop.



CONTENTS OF CONTROL PANEL(INSIDE- REAR VIEW)



LITHIUM LOOP HEATER CONTROL BOARD--REAR VIEW

CONTROL PANEL--CONTENTS [1-49ff]

Item	Description

1. Ammeters for 208V heaters. (usually mains and radiators). Full scale 20 amperes. In series with fuseholder, Littlfuse cartridge type (generally 10 or 15 amp fuse). [2-1976]

2. Ammeters for dimmer-controlled 120V trace heaters. Full scale reads 80, divide by 16 to obtain amperage full scale of 5 amperes. [2-1976]

3. Dimmer assemblies for 120V heaters. Ten assemblies in each of two aluminum boxes. Assemblies cooled by fan 19. Each assembly consists of: [1-58]
   a.) Dimmer switch. 120V, 600W for resistive load only. Brand Teri #6104, or Dim-a-lite #DAL 6P. [12-1977, 8-78]
   b.) Pilot light socket for NE-51H neon pilot lamp. Requires series resistor (wired into assembly).
   c.) Fuseholder, cartridge type HKP for Littlfuses. Sizes of fuses: 1,2, on up to (most common) 5 amperes.
   d.) 1P1T toggle on-off switch (dimmer push-on/push off knob prevented from operating by cylindrical spacer on shaft).

4. 2P2T relay with 120V coil. Relay is released by scram. Normally relay holds NO pole shut on police alarm system. Normally relay holds NC pole open for recorder drives.

5. Variable transformer for circuit "LM". 208V, 8 ampere. General Radio V20H. [ChE Instr. Shop #B20-407]

6. 3P1T relay with 120V coil. Relay is released by scram when the mode switch is in automatic position. Delivers maximum 30 amperes @ 208V per pole from feed circuit #33 to control circuits "JK" through "PQ". [3-1976; physical plant shop]

   Fuseholders for 3 phase feed circuit #33. Cartridge type for 30-35 amperes. Renewable link fuses. Control circuits "JK" to "TU" are fed through these fuses.

7,24. Controller for 208V control circuit "JK". Barber Colman brand.
   a.) PID controller. Model 622A-20860-031. 683A. Chassis A6060-400 (SCR). Serial 86K1221. [UW #241024]
   b.) Digiset setpoint and comparator, for type J (iron-constantan) thermocouple (in thermal well in lower lithium manifold). Model 380D. Serial 86K3508. [UW #241023]
   c.) SCR final output element, 15 amperes @ 208V, 3.1 kVA. Serial 86K1174. [UW #241025]

CONTROL PANEL--CONTENTS (CONTINUED)

Item	Description
8.	2P2T toggle switch for mode of relay 6. (main heaters). Auto(scram system)/manual(on). Blocking bar prevents accidental switching to manual mode; remove bar to switch to manual. 120V coil. [5-44]
	1P1T toggle switch, spring-open, manual enable switch for the relay 6 must be held shut with a special key in order to allow main heaters to operate in the manual mode. Operator usually carries the key.
9.	4P2T relay with 120V coil. For auxiliary heater control. [5-20,44]
10.	1P2T relay with 6V coil. Pilot relay for relay #9. Potter Brumfield type KRP5A, plug-in. [10-1978] [5-44]
11.	Transformer 120/6V for pilot relay 10 and its associated circuitry. [5-44]
12.	2P2T relay with 120V coil. NC contacts. If main heater power goes off (e.g. in scram) the relay lets go and the contacts close to a.) provide power to pump slowdown servo motor and b). power to radiator damper servo.
13.	2P2T relay with 120V coil wired in parallel with the electromagnetic pump pilot light. This pump/main heater interlock relay opens if pump is off and if the main heater mode is "auto", prevents the main heaters from operating, by preventing relay 6 from closing. [5-38,44,67]
	1P1T toggle switch override for relay 13, shunts around relay to allow main heaters to be on even if pump is shut off.
14.	2P2T toggle switch. Mode switch for relay 9 auxiliary heater control. One pole is for relay, one pole is for pilot lamps: Auto mode=orange lamp. Manual/on mode=red lamp. [5-20,44]
15.	Variable transformer for circuits "NO", "PQ". 208V, 30 amps maximum total. Superior Electric Co. [ChE Instr. Shop]
16.	Variable transformer for circuit "RS".* 208V, 15 amps maximum. Superior Electric Co. [ChE Instr. Shop]
16a.	SCR final element for controller & circuit "TU"* Rated 25 amps. Do not exceed 15 amps. See also 21a. 208V on/off output.
*	NOTE circuits "RS" and "TU" fed directly from input fuses; not through relay 6 (i.e., unaffected by scram system).

CONTROL PANEL--CONTENTS (CONTINUED)

Item	Description
17.	Fuse blocks & 6 fuses, plug type, 20 amperes for 120V trace heater control circuits 41-50,51-60 from feed circuits #27,21.
18.	4P2T relays with 120 volt coils (Two relays). Delivers maximum 25 amperes per pole at 120V. Potter Brumfield PM17A4. Automatic mode (not used but available) turns relays on in a scram. Manual mode (used exclusively so far) turns relays (and heater control circuits) on at all times. Wiring is through the NC side of the relay.[3-1976]
	1P1T toggle switch for mode of each relay 18. Terminal barrier strips -- hookup of feed circuits to dimmers.
19.	Fan for dimmer switch assembly boxes. Filtered intake. Forces cooling air through the boxes. 120 volt.
20.	Handibox with 2 duplex outlets. 120V, fused for total 5 amps. Used for: controller(s) 21&24, Digiset, fan 19, transformer 22, and/or digital thermometer 21.
21.	Digital thermocouple readout for type K (chromel-alumel) TC. Jumper-selectable for Fahrenheit/Centigrade but tends to stay in Fahrenheit. Brand and model number : Fluke #2160A/K single-point. Serial 455103. [UW # 415509] Replacement chip 3127-403527 [10-1978]
21a.	Controller for 208V control circuit "TU". Time-proportioning control from a type K (chromel-alumel) thermocouple selected from those on loop (currently used to control radiator temperature). Omega model 4001KF/T. Setpoint and indicator in Fahrenheit degrees. Triac output option. Serial 3011. See also output SCR, item 16a. [UW #448882]
22.	Control for radiator damper. Proportional opening to set position. Honeywell Modutrol type. Relay 12 provides power in a scram, or attached 1P1T toggle switch shunts power for manual operation. [ChE Instr. Shop]
23.	Transformer 120/25V with 1 ampere secondary, for radiator damper control item 22.
24.	Controller for circuit "JK"--see item 7.

CONTROL AND SAFETY SYSTEM

Component	Description
K1	Relay. 3P1T, NO(normally open). 208V to main heaters. Circuit #33 supply.
K2,K3	Relays. 4P2T. Wired NC. 120V to trace heaters. Circuits #21,#27.
K4	Relay. 4P2T. For auxiliary control of heaters. Wired NC.
K5	Relay. 2P2T. Wired NO. Electrical latch for scram system.
K6	Relay. 1P2T. Pilot for K4 auxiliary heater control. NO.
K7	Relay. 2P2T. Wired NO. Pump/Heater interlock.
K8	Relay. 2P2T. Wired NC. Pump slowdown & radiator damper.
K9	Relay. 2P2T. Wired NO for police scram alarm. Wired NC for recorder(automatic mode)turnon.
K10,K11	Relays. Convert 6V short-out level probe signal to 120V scram signal switch. Wired NC for high level probe. Wired NO for low level probe.
K12	Relay. 1P1T. Wired NO. Opens on main heater overtemp.
R1	Resistor. Variable adjustment, wirewound type. Adjusts voltage to smoke alarm lamps.
R2	Resistor. In series with lower smoke alarm lamp to lower the light intensity (shorter light path than top lamp.)
L1,L2	Lamps for smoke alarm. 120V, 6Watt. Screw base.
L3,L4	Pilot lamps for short-out level probes. 6V, bayonet base.
Q1,Q2	Photodiodes for smoke alarm. Transistor type MRD3051.
T1	Transformer. 120/6 V for auxiliary heater control.
T2	Transformer. 120/25 V for radiator damper control.
T3	Transformer. 120/6 V for short-out level probes.
T4	Constant current supply for continuous level probe.
T5	Transformer. 120/10 V for low-flowrate alarm buzzer.
TI1	Temperature indicator. Capacitance type, K thermocouple on main heater outlet. Opens K12 on overtemperature.
TI2	Temperature indicator. Solid state type. K thermocouple generally devoted as backup to TI2. Opens S15 on overtemperature. (recommended)
MV1	Recorder. Potentiometric type for millivoltages from continuous level probe. Opens S12 on low voltage(high lithium level). Opens S13 on high voltage(low level).
MV2	Recorder. Potentiometric type for millivoltages from flowmeters. Opens S14 on low voltage (low flow).

CONTROL AND SAFETY SYSTEM (CONTINUED)

Component	Description
S1	2P2T switch for main heaters. Auto(safety)/manual(on).
S2	2P2T switch for auxiliary heater control. Auto(control)/ manual(on). Second pole pilot lamps:auto=orange,on=red.
S3	Switch (interfaced to an auxiliary controller at the operator's option) for auxiliary heater control. 6Volt.
S4,S5	1PIT switch for trace heat control. Open=automatic(trace heat only on in scram)/Closed=manual=on. These switches are generally left in "on" position.
S6	1P1T switch for radiator damper. Auto (goes on in scram) Manual is on. Controls power to damper servomotor.
S7	1P1T microswitch (limit switch) opens to shut off pump slow-down servomotor after pump speed is reduced.(NC)
S8	1P1T spring-normally open switch for manual enable of main heaters.
S9	1P1T switch for overriding pump/heater interlock.
S10	Short-out (NO) lithium level probe. Closes on high level.
S11	Short-out (NC) lithium level probe. Opens on low level.
S12	1P2T microswitch wired NC on continuous level indicator. Opens when voltage goes lower than limit (level goes hi).
S13	1P2T microswitch wired NC on continuous level indicator. Opens when voltage goes above limit. (level goes low).
S14	1P1T mercury switch set NC on flowmeter recorder. Opens on low flow rate reading.
S15	Switch or relay, NO, on recommended main heater over-temperature (backup) monitor TI2. Opens on high main heater temperature.

CONTROL AND SAFETY SYSTEM (CONTINUED)

Event	Control or Alarm Response
1. Pump off. (except w/S9 closed.)	K7 opens. Main heaters off. See event 3. S14 opens. Low flow buzzer(unless MV2 off).
1a. Pumping slowed but not switched off.	Loop may overheat. See 4, 5, 6. S14 may open and low flow buzzer sound.
2. Main heaters switched to manual w/S1(unless S8 is closed).	Main heaters off. See 3.
3. Main heaters lose power(breaker #33 open, feed fuses blow, or cases 1 and/or 2).	K4 closes. Auxiliary circuit,if used, goes on (if not already on). K8 closes. Damper moves to preset (usually closed) position. K8 closes. Electromagnetic pump slows. Loop cools. See 6.
4. Main heater overtemperature.	S15 and/or K12 opens. Loop SCRAMS.See 10.
5. Loop overheats.	Lithium expands. Main heater may overheat. *K10,S12,S15,K12 may open. SCRAM. See 10.
6. Loop cools.	Lithium may freeze, in radiator first. Flow stops; see 1a. Lithium shrinks. *S13,K11 may open. SCRAM. See 10.
7. Lithium leaks.	S13, K11 may open.*SCRAM. See 10. Fire may start. Smoke alarm (if in system) may SCRAM. See 10.
8. Surge tank overfilled or drained too far by operators, or level goes momentarily beyond set limits (e.g. during vacuum)	S12, S13, K10, or K11 opens* SCRAM. See 10.

*NOTE: K10 opens when S11 closes.
K11 opens when S10 opens.
These are the short-out probes.

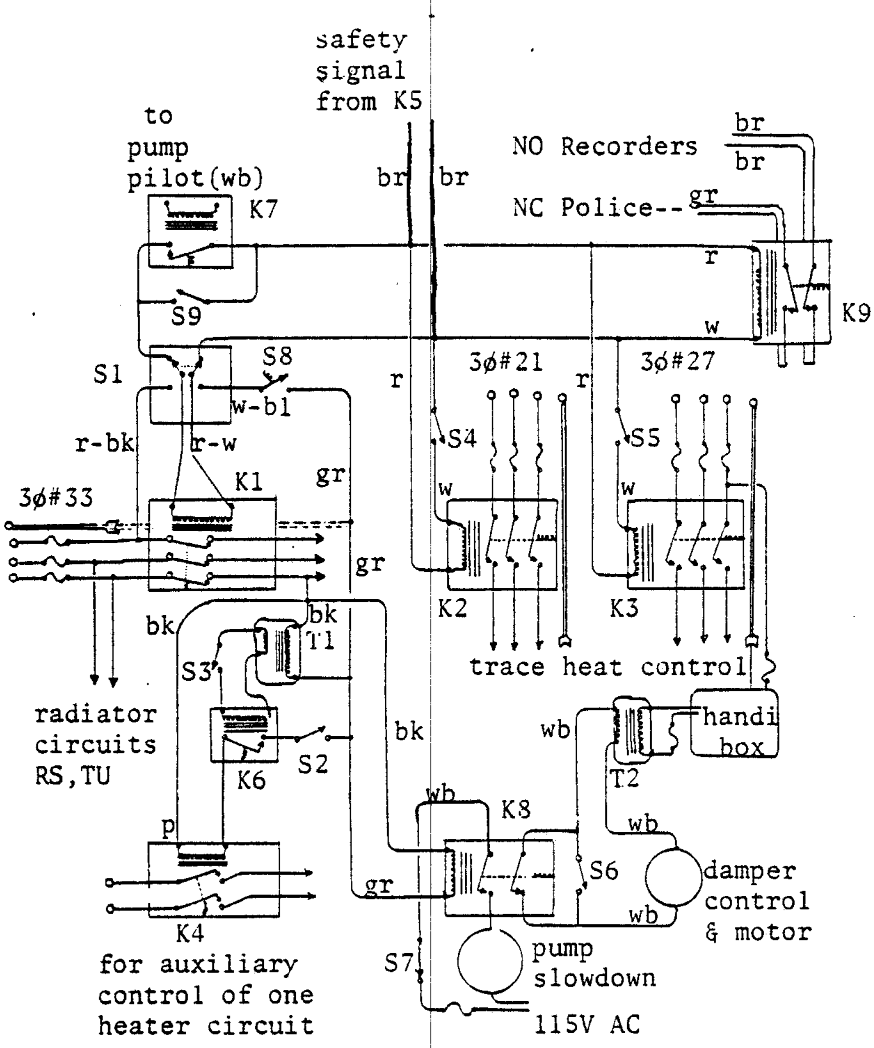
CONTROL AND SAFETY SYSTEM (CONTINUED)

Event	Control or Alarm Response
9. Power fails.	SCRAM. See 10. When power restored: Pump is OFF. Must be restarted manually. Operator must be on hand to monitor and/or turn off trace heaters which will go on with the power. If power failure is long, loop will freeze and application of trace heat may rupture pipes.
10. SCRAM	K1 opens if in automatic mode. Main heaters off. K2, K3 closed. Trace heaters on. K4 closed. Auxiliary heater on. K5 opens. This latch relay must be closed manually to terminate scram. All safety switches S12-S13-S15 and relays K10,K11,K12 must first be shut and smoke alarm, if in system, reset, before K5 latch will hold shut. K8 closes. Pump is slowed down if servo is plugged in. Damper is moved to preset position if damper control is in auto mode. K9 closes one pole and starts recorders if recorders are in auto mode. K9 opens other pole and alarms University Police Department.
Scram checkout procedures:	---- Police send security officer to lab. ---- Police phone or page operator. ---- Operator comes to check lab. ---- Operator or officer calls Fire Department if necessary. ---- Officer calls fire department immediately if there is obviously a fire.

In a scram, pump, trace heat and radiator heat stay on.

In a scram, pump may be turned off by turning off:breaker #16
main and radiator heat completely off:breaker #33
trace heat may be turned off at breakers #21,#27

NOTE THAT THE UNDERLINED STATEMENTS SHOULD BE TRUE DURING NORMAL OPERATION AND THE DOUBLY UNDERLINED STATEMENT MUST BE TRUE.

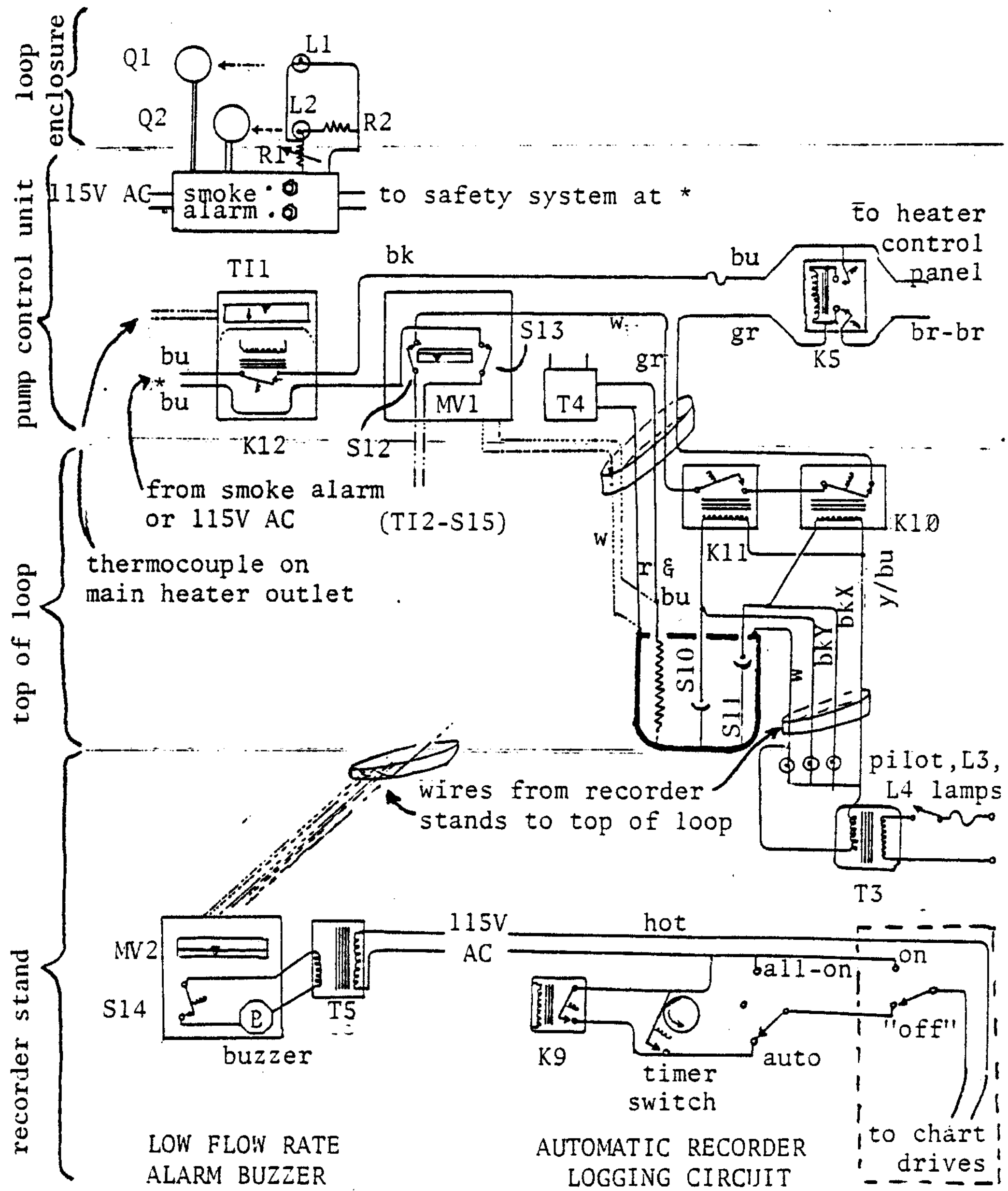


control wire legend

r=red br=brown
p=purple bk=black
w=white gr=gray
wb=white braid

[5-20,32,35ff,44,144]

CONTROL AND SAFETY SYSTEM--
INSIDE OF HEATER CONTROL PANEL

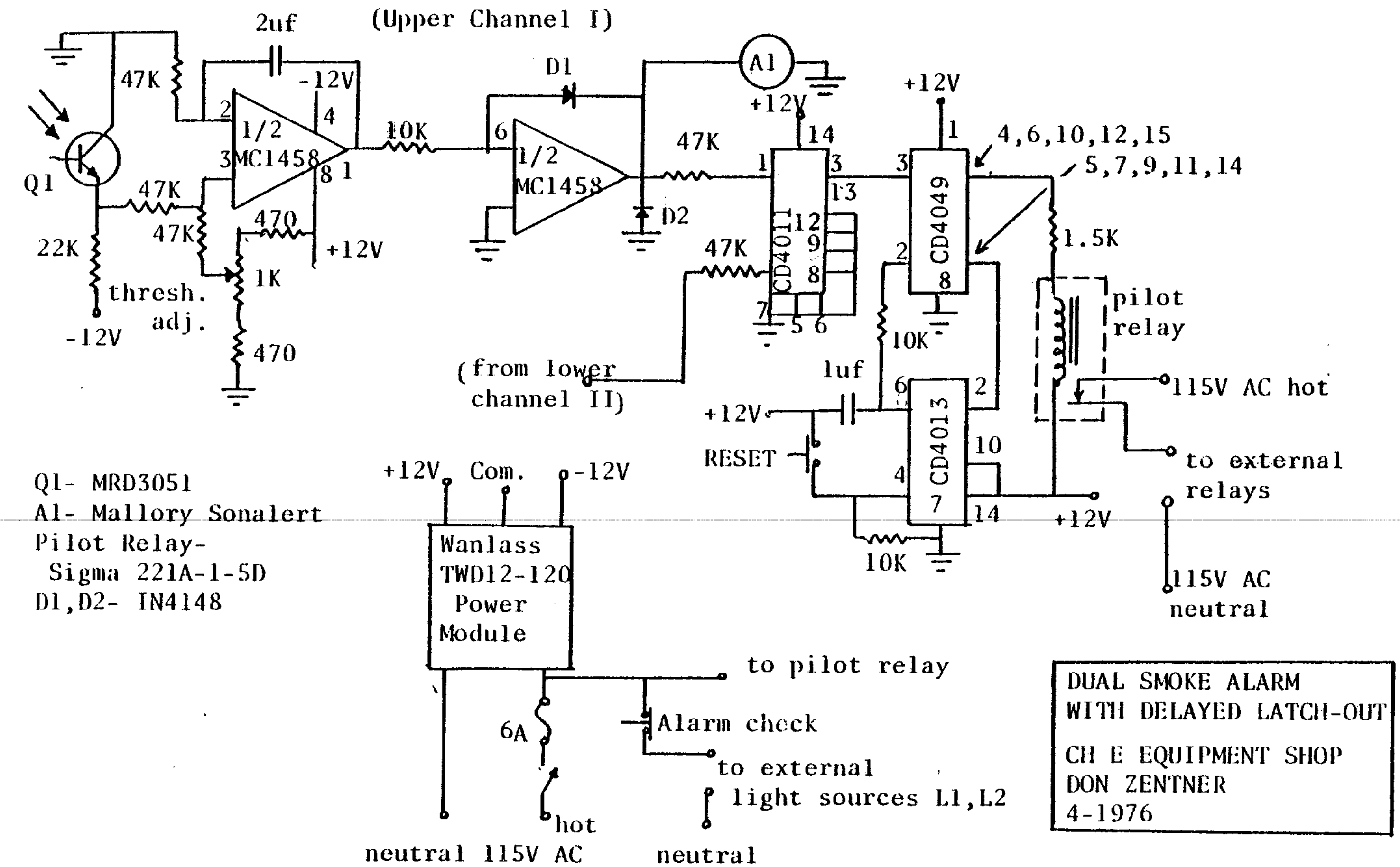


control wire legend

w=white gr=gray
y=yellow bk=black
bu=blue br=brown

[3-124]

CONTROL AND SAFETY SYSTEM ALARM SWITCHES
AND AUTOMATIC LOGGING CIRCUIT



SMOKE ALARM ELECTRONIC CIRCUIT DIAGRAM

APPENDIX J. MAINTENANCE OF LOOP

Data Logging

Maintenance and Repairs

DATA-LOGGING AND MAINTENANCE

DAILY:
- Write date and lithium level on strip chart record.
- Check maximum and minimum temperatures of loop; check general appearance of temp records.
- Check power settings.

WEEKLY:
- Check pager for correct operation.
- Record the meter outputs, using a potentiometer.
- Check argon pressure in surge tank (this can be done more often than weekly.)
- Check argon pressure in supply cylinders.

MONTHLY
- Record all thermocouples and all power settings.
- Check operation of smoke alarm.

BETWEEN STRINGER SERVICINGS
- Record meter outputs, using a potentiometer.
- Check tightness of valve nuts and stems (gas valves).
- Check continuous level output against level of frozen lithium in standpipes or against level of lithium seen on the fisher rods after removing them from loop.

EVERY 3 MONTHS
- Take a sample of lithium and analyze it.

EVERY 6 MONTHS
- Check all vacuum tubes in instruments. Replace weak ones.
- Oil the dimmer fan and the SCR fan for "JK".
- Unroll the stripcharts, accordion-fold them, label them and store in manila folders.
- Replace the filter on the dimmer fan if needed.
- Re-ink the recorders.

Reorder argon, chart paper, etc. as required.
Replace the chart paper as needed.
At each stringer service, generally let the alarm sound at the Police station (after warning them in advance) to check the alarm's operation.

NUMBER 103 LITHIUM LOOP DATA SHEET

DATE March 19, 1980 TIME 7:20-8:00AM OPERATOR D Bauer

TEMPERATURES IN DEGREES FAHRENHEIT

ELECTROMAGNETIC PUMP

#1	899	#2(a9)	883
#3	895	#4	886
#5	119	#6(c9)	404

HEATER

#15	930
#17(alr)	894
#19(c10)	922

MFOLD

#16(c11)	916
#18(c12)	922
#20	906

SURGE TANK

#95	758	#96(a10)	765

TOP MANIFOLD

#97	886	#98	914

PULLER PIPES

#75	——	#76	——

ISOTHERMAL ZONE

#G(c1)	916	#L(c2)	915	#Q(c3)	913	#V(c4)	917
#H	918	#M	916	#R	913	#W	XX
#I	919	#N	917	#S	915	#Z	920
#J	920	#O	917	#T	915	#31	919
#K(c5)	919	#P(c6)	918	#U(c7)	916	#32(c8)	922

ELECTROMAGNETIC PUMP PIPING

#85	678	#86	886	#87	884	#88	886	#89	889

RIGHT

#77	501

FRONT ECONOMIZER PIPING

#75(a5)	652	#76	796	#77	623	#78	901	#79(a7)	870	#80	684

RIGHT END PIPES

#G(a8)	854	#K	378
#I(b12)	608	#L(b5)	629

REAR ECONOMIZER

#P	790	#S(a6)	733	#Z	770	---	——

FROM METER TO ISOBOX

#X91	919	#X92	918	#X93	912	#X94	919

C'TRAP / RADIATOR ZONE

C'TRAP		RADIATOR ZONE					
#Q(b8)	426	#T	612	#2	606	#8	586
#R	333	#U(b6)	613	#5	XX	#9	588
*	282	#V	603	#6	594	#1	603
**(b9)	239	#W	596	#7(b7)	592	#16(ctl)	609

BETWEEN MANIFOLD AND METER

#X81	XX	#X82	918	#X83	921	#X84	921

DUMP TANK

#J	497	#K	495

THROTTLE VALVE: BELLOWS ZONE

#X71	634	#X72	733	#X73	759	#X74	758

SHIP TANK

#N	77	#O	75

FREEZE ZONE: TOP PART

#67	215	#68(a2)	219	#69(a3)	207	#70(a4)	...

DUMP VALVES

HIGH(a11)	LOW(a12)
265	384

FREEZE ZONE MISCELLANEOUS

---	#Y78	#Y79	#Y80
XXX	335	570	317

ELECTRICAL HEATING SETTINGS / METER READINGS

D41 30	D42 30	D43 32	D44 22	D45 32	D46 26	D47 36	D48 34	D49 30	D50 28
D51 46	D52 50	D53 70	D54 OFF	D55 56	D56 30	D57 30	D58 14	D59 28	D60 LOW

JK set: 932 read: +1.5	amps 11A	LM 190V 5A	NO 74% 12A	PQ 74% 6A		RS 42% 8A	TU set: 620 read: 606 amps 12A

ELECTROMAGNETIC PUMP
%set: 10% V: 50 I: 6.3

OVERTEMPERATURE
read: 467 set: 520

ELECTROMAGNETIC FLOWMETERS
#1 1.17 #2 .59 #3 .34 #4 .82

PRESSURE GAUGES
TOP MFOLD: DUMP:
COVER: FLOOD:

LEVEL SENSORS
CONTINUOUS read: 23.8 hi set: 21.2 lo set: 25.2
ON / OFF high: XX low: ON

10/20/79

LITHIUM LOOP SAMPLE DATA LOG SHEET

Maintenance

Routine repairs which have been made are described in this section. Suggested remedies for foreseeable problems are outlined. Speculations are made on how to fix a few problems that would require extensive work.

Maintenance jobs are arbitrarily categorized below.*

Repairs that are not difficult

- Removal and replacement of side panels
- Servicing thermocouple extension connections inside loop
- Tightening heater terminals (on the heater)
- Repairing broken tubular heater terminals
- Servicing smoke alarm lamps
- Servicing smoke alarm photodiodes

Repairs that are moderately difficult

- Servicing external radiator heaters
- Servicing thermocouple connection box
- Servicing heater junction box
- Servicing radiator ductwork, damper, etc.
- Servicing ball valves and adapter pipes
- Servicing electromagnetic flowmeters

Repairs that are more difficult

- Removal and replacement of enclosure roof panels including removal of flow valve setting disks
- Servicing of fill tubing between shipping and dump tanks including filters
- Servicing level probes on surge tank
- Removing a trapped gas bubble from loop

Repairs that are extremely difficult (not attempted to date)

- Servicing radiator housing, and ductwork removal
- Replacement of tubular heaters
- Replacement of isothermal oven strip heaters
- Removal of isothermal oven from around test sections

* Unpredictable problems such as high temperature wear-and-tear (e.g., stuck bolts) may make some repairs more difficult.

Repairs that are not difficult

Remove side panels: If necessary to turn off the pump for safety, try to wait until a stringer servicing operation when the pump is turned off anyway. Unscrew the 1/4"-20 x 1/2" long hexagonal bolts bolts which hold the panel to the frame. Most of the panels have a lip which fits inside the next lower panel. Lift the panel being removed up about 2" to disengage the lip; remove the panel. Replace side panels by repositioning the panel and replacing the holding bolts. Use a 1/4"-20 tap to help position holes which are hard to line up. Use a nut-driver to help speed up the tightening of the bolts.

Service thermocouple extension wires within the enclosure: Untape the extension-to-thermocouple splice. Cut the splice off, noting the polarity of the wires. Connect the thermocouple extension wire to the desired thermocouple and check the polarity with the digital thermocouple readout. Splice one side of the connection using a butt type crimp-on splice. Tape the splice with Scotch #27 glass cloth electrical tape. Splice the other side of the connection and tape the entire splice.

Tighten heater terminals: Turn off the circuit's power. (Remember that heaters wired with 208 volt power are always "electrically hot" unless the #33 hall breaker is "off" or the selector switch appropriate to the particular heater is in the "center-off" position in the heater terminal junction box. Do not switch the selector under load.) With a small wrench or electrical pliers hold the inner nut on the tubular heater terminal and with a second wrench tighten the outer nut gently. (The power-wire lug will be held between the two nuts and a pair of washers.) Tape the terminals with #27 tape. Turn the power back on.

Fix a broken tubular heater terminal (which may occur if threaded stud of a tubular heater breaks off): The heater can be repaired if enough of the solid metal stud remains attached. Cut off about 1/4" of the incoloy sheath with a tubing cutter or hacksaw, without cutting the central stud (bolt) which carries current into the heater. Clean the MgO insulation off the stud. Crimp an electrical ring-type lug onto the heater stud and secure this lug to the lugged hookup wire with a small bolt and nut. An alternate method is to cut a 1/4" long piece from a I/4" copper tube, debur it, slip it over the heater stud and slide the hookup wire (not lugged) into the tube. Crimp the tube onto the stud and wire, using a visegrips.

Service smoke alarm lamps: Turn off power to lamps. Access the upper lamp by unscrewing the sheet metal screws holding the lamp assembly to the right side of the radiator duct. Replace the bulb. Secure the bulb to the lamp base with a dab of RTV silicone rubber.

Access the lower lamp by removing the small piece of sheet metal from the enclosure back, just above the blower delivery duct.

Unscrew the lamp assembly sheet metal screws to unfasten the assembly from the blower duct. Replace the bulb and secure it to the lamp socket with RTV silicone rubber.

The smoke alarm lamp bulbs are 6 watt, 120 volts.

Service smoke alarm photodiodes: Top photodiode is at left end of radiator exhaust duct, just above enclosure roof. Unscrew the cable clamp holding the diode housing and remove housing. Have electronics technician check diode and possibly the smoke alarm (boxed circuitry; diode type is MRD3051. See appendix K).

Bottom photodiode is inside the blower duct across from the bottom lamp. Remove lamp as described above. Push the diode housing gently back through the duct wall to break off the silicone rubber holding it in place. Snake the diode coaxial cable out of the enclosure. To replace the diode snake the cable back into place and push the diode housing up through the cable clamp until the housing is flush with the inside wall of the duct. Use a dab of RTV to secure the housing; be careful not to obstruct diode with the silicone rubber.

Moderately difficult repairs

Service radiator heaters: The original heaters are inside the radiator housing and are very difficult if not impossible to access. The lowest heater burned out in late 1978. Its power leads were cut and taken to the front of the radiator where external heaters were then mounted to replace the burned out internal heater.

Three aluminum clamps were bolted to the steel angle ribs of the radiator housing at the lower front of the radiator. The clamps were fitted with bolts whose heads would support the replacement heaters while the clamps held them against the sheet metal of the housing. One of the two initial replacement heaters burned out in the fall of 1979 and the two were replaced by three heaters, one of which serves as a non-operating spare. The aluminum clamps had oxidized so badly that they could not be removed, but the heaters were slid in under the clamps. Another burned out in a few months.

A major part of the replacement effort is the rearrangement of insulation necessary to access the front of the radiator.

Move the insulation aside. The corners of the bottom rear insulation blanket must be unwired and dropped back from the front. The front insulation and the triangular pieces connected to the bottom of it must be rolled upward and tucked between the economizer and the radiator. This exposes the lower part of the radiator housing. Thermocouples through the insulation to the lower duct must be slid out of (drilled-out bolt) fittings before rolling up the insulation.

Tape the heater terminal connections with #27 tape. Reposition the radiator insulation as originally found.

In April 1980 one of the aluminum clamp bars holding the radiator external heaters apparently loosened and dropped down onto the electromagnetic pump, where it shorted the pump secondary to the radiator housing. The aluminum apparently melted, judging from the glass insulation nearby which also was melted and was sooty, apparently from some of the pump insulation which may have burned when hit by the hot aluminum. About 200-300 cubic centimeters of aluminum dust or oxide eventually fell onto the back of the pump table. Fiberglass insulation below the pump had several small holes which molten Al must have made in passing. The pump did not blow a fuse, but may have been slightly weakened; it was necessary to set the pump at 12% to get the same flowrate signals previously attained with a 10% setting.

Heater clamps should in the future be stainless steel and constructed so that no bolts need be loosened in replacing heaters. The radiator sheet metal is severely buckled by the heat and probably should be heavier gauge, and perhaps stainless steel rather than the galvanized steel used. It is too late to conveniently fix this, and probably not really necessary.

Service the thermocouple connection box (at the left back of loop enclosure) Pull out the thermocouple recorder plugs. Unbolt the box from the top of the enclosure. Being careful of the extension wires entering the enclosure from the top of the box, flip the box over onto the top of the enclosure. Drill out the rivets holding the back plate of the box. Remove to expose the interior of the box, where connections of the extension wires from the loop are made to the phone jacks. Connections are with miniature brass bolts and nuts (#2-56x3/16") since chromel and alumel do not solder very well. Connections should be secured with a dab of Duco cement.

Service heater junction box (front right of loop enclosure, near floor) Work must be done quickly and efficiently, since the power should probably be turned off and the loop will therefore be cooling. The loop should not be allowed to cool below 250C . Work is best carried out with the pump moving lithium through the loop and work should be started with the lithium temperatures rather high (that is, routine operating temperatures.)

Turn off all heater power. (Hallway breaker box, circuits #21, #27, #33.) Unscrew the four corner bolts holding the masonite board in the box. Carefully tip the masonite out, reaching behind it to pull forward the two bundles of wire entering the loop. It may be necessary to tug quite hard, but carefully, to get enough slack to tilt the masonite down. (NOTE--the bundle of supply wires entering the bottom of the box has no slack; do not pull it.) After quickly fixing any bad connection, tape it with plastic electrical tape. Do not attempt to make many repairs at one time if this will allow the loop to cool very much.

Push the two bundles of wire back through the conduits into the enclosure to allow the masonite board to be replaced. The wires may have to be pulled from inside the enclosure; do this with care after removing the panel to the left of the heater terminal box in order to reach inside the enclosure. Replace and carefully tighten the four corner holding bolts (3/8"-16 size).

Service radiator ductwork, damper, etc. Repairs should be made when the radiator is relatively "cool" during stringer servicing; heat may be reduced below regular level for additional safety. Pump should not be on since the operator may have to reach inside radiator. Damper can only be accessed by reaching through the filter door (in the upper duct) and removing the prefilter. Taking care not to damage the HEPA filter above the access door, reach down into the duct. Long arms are necessary. The damper is riveted to the back of the duct with aluminum rivets ("pop" rivet AA46D, drill hole with #30 drill. These rivets are used extensively in the radiator duct and other loop equipment.) The piano hinge of the damper has been lubricated with LP-9 or WD-40 spray. Any routine repairs to the radiator will be very makeshift due to the cramped working space.

Service ball valves: Be certain the freeze plugs are really formed below the ball valves--check the temperatures of the freeze zone standpipes with thermocouples and by touch. Generally lithium should not be flowing in the loop if ball valves will be opened or removed. Close all gas valves (ball valves shut too) at the top of the loop. Remove insulation from standpipes; let them cool further.

Disconnect the Swagelok end of the adapter pipe gas tubing gooseneck from the associated tee on the gas manifold. Unbolt the lower ball valve, using a ratchet wrench with a long extension to remove the 1/4"-28 bolts. It may be necessary to jiggle an adjustable wrench onto the nuts in order to unscrew the bolts. The bolts go through the upper flange (on the adapter pipe) and then the valve body, and finally through the lower flange (on the freeze standpipe) before being secured with the nuts.

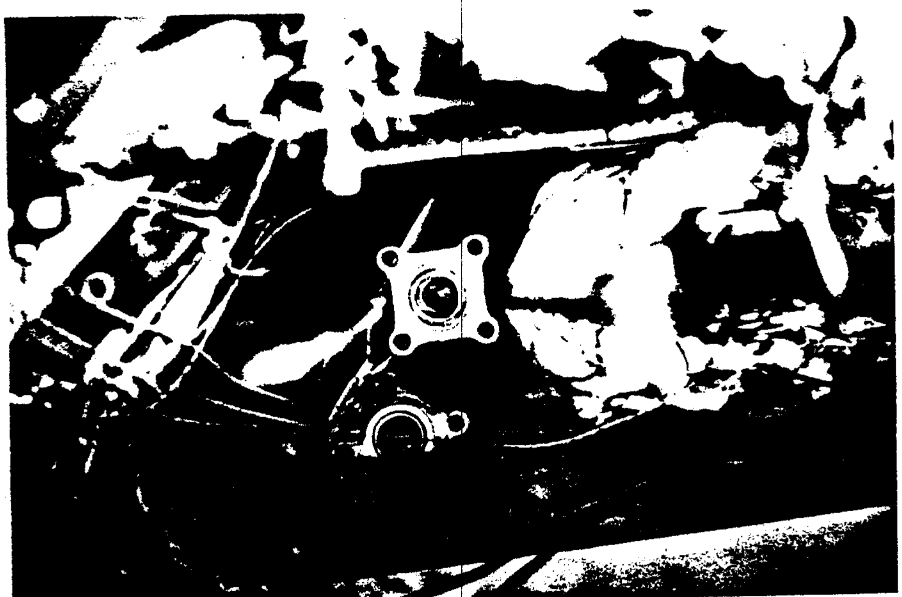
When using the ratchet wrench do not make use of the handle as a lever. The wrench should be held with the knuckle of the index finger in a line with the bolt, socket, and extension of the wrench. By gripping the wrench on the ratchet end rather than the lever end the possibility of overtightening the bolts is reduced.

Remove the ball valves and adapter pipe and clean parts as needed. If necessary, the upper brass valve may be removed from the adapter pipe by clamping the pipe tightly in a vise with pipe jaws --taking care that the gooseneck tubing is not bent during the clamping or while removing the valve. Use a large open-end wrench to loosen the valve, taking care not to damage the nut or stem.

Lithium-affected parts of either valve should be cleaned with hot water (cool water if there is much lithium) and when the parts are clean, they should be rinsed liberally with hot water, then distilled water and finally isopropanol or methanol before a short drying in an oven at 130 C. If it is necessary to replace a ball or ball seal on either valve, check that the stringer and shroud will pass through the replacement part. Ball seals usually must be reamed out slightly over 9/16" with a hand-reamer. Replacement balls must be drilled out 9/16" oversize in a lathe. This is not a time consuming job but does require special care to assure the ball valve is lined up properly before drilling.

The ball and body seals of the lower ball valves should be replaced whenever the valve is disassembled, since the ball seals usually have a little lithium on them and the body seals have been compressed and should not be relied on to make a good seal.

The lower flange of the bottom ball valve is welded onto the freeze standpipe. Once lithium rose into this valve and beyond it 6 inches. When the cooled valves were taken apart, a very hard lithium nitride deposit was found for about 1/2" in the freeze standpipe flange just below where the lower ball valve had been. With some difficulty this nitride was carefully chipped out as well as possible. The outermost layer of nitride was an extremely hard shiny black material. The deeper nitride was a reddish brown which we have subsequently encountered most frequently.



REPAIRS -- PLUGGED STANDPIPE
BALL VALVE REMOVED FROM STANDPIPE
STANDPIPE IS COOLED FOR SAFETY
LITHIUM IN STANDPIPE IS FROZEN

Lithium or lithium nitride deposits in the standpipe just below the lower ball valve may obstruct the passage of the stringer and must be cleaned out. The lithium should be frozen as high up in the standpipe as it can safely be filled. In some cases, this will require removing and cleaning the ball valves (to allow gas to pass freely through them) and then reassembling the valves onto the standpipe, thawing the lithium there under argon, and raising the level before refreezing. The higher the lithium in the standpipe, the safer it will be working to clean out the top of the pipe, since the extra lithium forms a better thermal fin and a stronger plug against the liquid lithium down below.

The standpipe should be clamped to the enclosure frame with the U-bolt provided for this purpose. Care should be taken during the cleaning operation to avoid using unnecessary force or torque on the standpipe. Careful use of wedges is an alternative to clamps.

Crusts of nitride may be partially removed with a punch, screwdriver, or electric drill and 1/4" bit. Care must be taken not to score the machined surface of the standpipe flange or it will not seal to the ball valve body. A 9/16" hand reamer held in the end of a visegrips or in the chuck of a hand brace (not a power drill) may be effective in removing nitride on the sides of the pipe. The reamer is not very effective for removing large amounts of material or for lithium. A 9/16" bit turned carefully (to avoid biting into the throat of the flange or sticking into the lithium or nitride) can remove both lithium and nitride. The cleaning must proceed until all nitride has been removed, then 1/2" further. The end result should be a clean surface of lithium within the standpipe. The standpipe should be empty of lithium for at least 2-1/2" below the flange. Nitride can be removed from the walls using a variable speed electric drill and a 1/2" or smaller burr. Do not overheat the nitride when deburring or it may start to burn. In all cases be careful not to dig into the lithium or nitride with a tool, electric or otherwise, deep enough to catch the tool in the deposit. This will be difficult to remove in some cases, and indicates too much force is being used; remember the standpipe is poorly supported and cannot take much stress. A stalled electric tool, in particular, can develop a great deal of torque.

In most cases it is desirable to clean out the nitride and lithium which is removed from the pipe. A vacuum cleaner may be used for this purpose. Tape a foot long, 1/2" diameter stainless tube into the vacuum hose. Use this to suck nitride dust and debris as well as small chunks of lithium out of the standpipe as it is being cleaned. Much of the debris will end up in the transition where the vacuum hose meets the smaller tube; dust will be carried into the vacuum bag.

When the standpipe is cleaned, clean the flange with damp cloth and wipe it with alcohol. It may help to protect the flange if it is covered with masking tape during the cleaning, but the residue of the tape must be completely removed. It may be necessary to carefully scrape lithium or nitride off the flange if much has deposited there. Finally, replace the ball valves.

Both the ball and body seals of the lower valves, as previously mentioned, should be replaced whenever the valves are taken apart. The ball seals must be reamed out 9/16" oversize. Make sure all seals are in proper position.

The gooseneck tubing from the valve assembly to the gas manifold should be fitted into the Swagelok before tightening the four bolts which hold the lower ball valve together. The nuts should be put on the bottom of all four bolts and tightened by hand. A puller shroud tube should be placed into the valve assembly to assure that it is assembled in line with the standpipe and with the flanges matching the body. While tightening the four bolts, the shroud should be occasionally pulled out and the lower valve tested to see if it will close freely. The shroud should then be lowered back into the valve while tightening proceeds.

The four body bolts should be tightened in a balanced pattern, alternating diagonally opposite bolts so as not to warp the flanges. A ratchet wrench with a long extension should be used to turn the bolts. Although the wrench has a long handle, the operator should keep his hand near the center of the wrench so that the lever arm is not longer than about 2". The nuts below the valve may have to be held with a wrench slipped onto them. When the bolts do not tighten further or slip (with the wrench removed from the nut) the assembly is satisfactory. The Swagelok nut on the gooseneck gas tube should be started by hand to avoid stripping the threads; final tightening should be done carefully with a wrench. The tee on the gas valve should be held in a lightly clamped visegrips while the nut is tightened.

The ball valve assembly should be vacuum tested before melting the lithium in the standpipe. Any loud gurgling of the vacuum pump indicates that the assembly needs further checking or loosening and retightening. Check valve stems to see if they are tight.

It is not too difficult to use the above methods to clean a standpipe of lithium or nitride, provided that the blockage is less than perhaps 5-6" below the flange. Blockages deeper down would require special tools (e.g., long bits) and extra care for safety (perhaps freezing the entire pipe down into the test zone). In order to minimize contamination and blockage much below the flange, the standpipes should always be kept filled as high as safely possible, frozen, and under argon pressure to minimize inleakage of air. A positive pressure of argon should be maintained over the standpipe especially when the lithium is molten, with careful awareness of the added danger of a lithium leak at such a time (pressure on the loop would tend to release more lithium in the event of a leak). The loop should not be left long periods of time under a source of pressure. In particular this should not happen when the operator leaves the lab for more than five or ten minutes. [5-71,82;7-37,93,121,139]

Service magnetic flowmeters: Wait for a stringer servicing operation, if possible. Turn off the pump. Freeze the flowmeter section to be serviced. Remove the left middle and left bottom panels from the front of the loop enclosure. Remove insulation batts as necessary to access flowmeter. It will not generally be necessary to unwrap any pipes, which are insulated with Kaowool rather than glass.

Loosen the four 3/8"-16 bolts holding flowmeter to its aluminum table. Remove the bolts and the aluminum shims between the table and the flowmeter mounting plate. The flowmeter will drop about 1/2" but will not be free.

Loosen and remove the four stainless steel 5/16"-18 bolts holding the flowmeter to the base pillars. (Do not wear a wrist watch while working near the magnetic flowmeter.) Shift the base so that one end of the flowmeter can carefully be dropped down between the pillars. Remove the base. Remove the flowmeter carefully to avoid tearing loose the stainless steel electrode wires from the pipe. There are two pairs of electrodes; only one is run out by extension wire to external connections. The other is a spare.

Replace the flowmeters in the reverse order of the above steps. The test section pipe must be centered between the magnet poles. After loosely tightening the 3/8"-16 bolts (with shims in place between the table and base) shift the magnet back and forth gently to determine the position of the magnet relative to the piping.

Center the magnet about the piping, then firmly tighten the 3/8" bolts (the 5/16"-18 bolts have already been retightened during the reassembly procedure.)

Replace the insulation and carefully melt the lithium in the pipe, starting with a low heat. Replace the enclosure panels.

Difficult repairs

Remove roof panels: The roof panels are more difficult to remove than the side panels because of the support hangers going through the roof. In particular, the panel in front of the radiator and the panel through which the valve extensions pass would be difficult to remove. There are hangers at both ends of these panels, and removal requires springing the panels in order to clear the hangers.

Before removing the roof panel in front of the radiator, the ell shaped duct between the loop enclosure and the radiator exhaust duct has to be removed. Unscrew the sheet metal screws which hold the duct to the roof and to the larger duct. Remove the side pieces which clamp the top of the small duct in place. Lift the top off. Disconnect the pull wire from the small internal door between the ell duct and the exhaust duct. Lift the ell duct off the enclosure.

The roof panel in front of the radiator may now be removed. Unscrew the bolts holding the panel to the frame and struts of the enclosure. Untape the panel from the radiator and move any wires which are in the way. From beneath the panel (remove the front panel to get inside the loop enclosure) push upward to bow the roof panel so that the hangers at one end are cleared. This may be difficult since the panel is heavy gauge steel. Tilt the panel upward and out from under the hangers at the other end.

The roof panel over the valve extensions is removed in much the same way as the panel in front of the radiator. First, note the settings on the valve extension disks, then unfasten the disks <u>without turning the valves</u>. Hold the nut under the disk with a wrench to prevent it from turning, and untighten the upper nut to free the disks from the extensions so that the panel can be lifted off the extensions. This panel must also be bowed, or sprung, to get it loose from the hangers which are at either end. Be careful not to strain the valve extensions during removal of the panel.

Replacement of the roof panels is more difficult than removal since the valve extensions and/or hangers now have to be repositioned along with the panel's having to be sprung into place.

<u>Remove fill tubing between shipping and dump tanks</u>:

Swagelok connections along this tubing were overheated in August 1978 and leaked slightly, shorting out the heating tapes. The thermocouple readings taken along the tubing prior to overheating were suspected to be low, and extra heat was being applied to insure that the valves in the line would not be frozen. If the tubing is not again overheated, it may be okay to wrap new heaters on the lines and proceed cautiously. It has not been necessary to transfer lithium between the tanks since the leak was discovered (some months after it occurred). The lines are frozen at this time. The lines <u>must be frozen</u> if they are to be disassembled. It is suggested that the two tanks also be frozen.

The valve in the transfer tubing nearest the dump tank is OPEN--keep this in mind.

Unscrew the 1/2" Swagelok connecting the 15 micron filter (nearer the shipping tank) to the shipping tank side of the tubing. After breaking this connection, cap and plug the open fittings immediately. The shipping tank can be moved if desired, after unfastening its gas connection to the lower gas manifold. Note well the exact position of the shipping tank so that it can be replaced when it is to be reconnected.

There remain on the dump tank side of the tubing the two filters which leaked and a zee shaped dogleg tube between the filters. Some or all of these should be removed, cleaned, repaired or preferably replaced, and reassembled. Water followed with methanol and a good oven drying should be included in the cleaning.

Since overheating apparently did the most damage to the filters, there is no need to try removing the tubing which penetrates into the two tanks. These dip tubes extend to the bottom of their respective tanks and would leave a film of molten lithium on their Swagelok ports as they were drawn up out of the tanks. An argon cover gas purge would probably be maintained in the tank during such an operation, and some precaution must be made to prevent the lithium-coated dip tube from catching fire as it came out into the air. The tank would be immediately capped or plugged with the appropriate Swagelok fitting after the dip tube was out. The lithium inside the tank would be frozen after vacuuming out the contaminated gas and replacing it with argon. The tube should be cleaned and the nut and ferrules replaced if needed, before reinserting the tube as far into the tank as the level of frozen lithium would allow. Again under argon pressure the lithium in the tank would be remelted and the dip tube pushed in until it hit the bottom of the tank, then lifted back up no more than 1/4". With the dip tube thus correctly repositioned, the Swagelok would be tightened and an argon atmosphere should be refreshed by vacuuming and backfilling the tank.

Some trial and error might be needed to get the system of dump tank, shipping tank, filters and interconnecting tubing all lined up for reassembly. Proir to reconnecting the Swagelok fittings, a few fractions of an inch of offset between parts is acceptable, but larger mismatches will stress the Swagelok connections and make leaks more likely to occur. If the fittings leading to the shipping tank tee have been cleaned out the sampler port there may be used to vacuum leak test the assembly before exposing it to molten lithium. Heating tapes would then be wrapped around the tubing and insulation and thermocouples put in place. The tubes should not be overheated. A pale red heat is much too hot!

Remove level probes from surge tank: Take the insulation off the tank cover carefully, and, avoiding stressing the (unbraced) tank, loosen the swagelock nut holding the fitting in place. An argon purge through the tank is necessary at this point and there should be no lithium flow in the loop. The standpipes must be frozen as well. The operator may choose to drain the lithium just out of the surge tank and then try to freeze it in the upper lithium manifold. If there is any lithium holding the probe to the wall inside the tank or to the Swagelok (lithium may climb up the inside of containers) then the tank must be heated above the melting point of lithium (181 C; 357 F). It may be easier to remove the level probes from the surge tank than to get the dip tubes from the dump tank or shipping tank, since by design (although possibly not in practice) there should only be lithium on the central electrode of the probe, which may carefully be lifted out of the tank to prevent getting lithium on the Swagelok fitting. Precautions noted above in the section about the removal of dip tubes from the other tanks should be read carefully. Openings to the surge tank should be immediately capped or plugged and the tank vacuumed and backfilled with fresh argon. (See also next pages; [7-152; 6-25ff]).

Replacement of the level probes is preferred over their repair and reuse. The replacement probe may be made using a standard vacuum-passthrough fitting, or a modified spark plug. The standard fitting is simpler to use but the spark plug type may be sturdier against thermal stresses or mechanical shocks.

<u>Replace surge tank level probes</u>: Drain the surge tank, upper lithium manifold, and the inside pipe of the economizer, as described below for removing a gas bubble from the loop. No lithium in the loop should be above the level of the upper manifold; lithium in the outer economizer may be above this level if the pumping section of the loop is frozen. [7-152; 6-25ff]

Turn off the test section heaters (isobox and lead-ins), upper manifold and surge tank heaters. For safety, wait until the temperatures in these parts reach about 220C in the manifold, 150 C to 200 C in the test sections, and 180 C in the surge tank. Higher temperatures may still be safe, but not so safe as the values noted (in certain cases, slightly warmer temperatures may make it easier to free a stuck probe.)

If possible, use one of the other probes as a monitor to warn of any lithium rising into the surge tank. If any lithium does come into the tank, stop the replacement procedure, retighten the probe in place, and drain more lithium before proceeding.

Carefully loosen the Swagelok nut holding the probe into the fitting on the tank. The best wrench to use for this is a tee-handled wrench (like a tap wrench) which exerts a pure torque and minimizes sideways forces on the surge tank. Such a wrench which could be fitted over the top of the probe would be most convenient, since the close placement of the four Swagelok fittings on the surge tank makes working with a wrench from the side quite awkward.

If no wrench fits down from the top of the probe (e.g., a hollow-bodied socket wrench as used for automotive spark plugs) then use the smallest open- or box-end wrench suitable for the job. Try to hold the wrench so that when the Swagelok nut (normally stuck) releases, the wrench does not slam against your fingers or break one of the other probes. Use some finesse with leverage; try to apply force as a torque, rather than a push or pull, on the wrench. You may be able to counteract some of your pushing or pulling by holding the probe with your other hand. When the nut is loose, unscrew it off the tank fitting.

Loosen the probe from the fitting by twisting it with a wrench or a visegrips. Do not grip the ceramic part as it will break and leak. Wobble the probe if necessary to free the ferrule. Then carefully lift the probe out of the tank. No lithium should come into the tank and the only sound should be the hiss of the escaping argon cover gas (maintain a .5 to 1. psig argon purge through the tank during the cooling, repair, and reheating of the area.)

The probe should be lifted out of the tank without touching the central electrode to the Swagelok seat, as this will get lithium on the Swagelok sealing surface (which, in practice, may be hard to avoid.)

Use a hand-turned reamer or a hand drill to clean any lithium out of the fitting. Cotter-pin or tape the tool to prevent dropping it into the tank. Clean fitting quickly. In spite of the argon purge, it is important to minimize the time that the fitting is open.

Small amounts of lithium on the fitting are not too serious (remove anything that can be easily cleaned out) since lithium is soft and will not seriously affect the Swagelok seal. Lithium nitride, however, is hard and if the sealing surface is nitrided, it should probably be cleaned quickly but very carefully with a cheesecloth damp with alcohol or distilled water (not very wet, since any drops falling into the tank could cause a dangerous reaction with the hotter lithium down below.) Finish up with an alcohol wiping of the sealing surface, then put in the new probe.

The Swagelok ferrules on the replacement probe should have been tightened (seated) onto the probe tube beforehand, using a drilled-out fitting of the proper size (1/2" or 5/16") so that the length of the tube below the top ferrule is 1" and the length of the electrode wire below the top ferrule is 14".

About 1/2" of the probe tube will extend into the surge tank. This extension of the probe tube will hopefully prevent lithium from "wicking" across the inside of the surge tank roof and getting into the probe tube, where it will cause a short. The 1/2" diameter probe is more reliable in this respect, since there is a larger annular space between the probe tube and electrode for this larger probe.

Retighten the Swagelok nut to seal the probe into the surge tank. Again, try to using torque rather than pushing and pulling on the wrench handle.

Apply a partial vacuum (not more than 10" Hg lest a frozen plug of lithium somewhere should slip and allow lithium to spurt into the surge tank) and backfill with argon about 10 times to purge out the gas in the loop. Maintain 1 psig of argon in the loop. Carefully reheat surge tank, then manifold, then test sections. (If these were not cooled much below the temperatures recommended previously, it may be possible to reheat them all simultaneously).

There will be a large amount of argon in the economizer at this time. The procedure for removing a trapped bubble should be followed. (Before going to any great lengths to restore the loop to normal conditions, check the newly replaced probe to make sure that it hasn't shorted against the top or side of the tank.)

Check the calibration of the replacement probe. The best way to do this is to use the reading at which the probe output comes on scale (that is, when lithium hits the known level at the bottom of the probe) and the reading when the lithium has risen to another probe some distance above the one being calibrated. If there is no such probe to provide a second calibration point, calibrate the new probe roughly against the level in the dump tank as lithium is moved at atmospheric pressure between the two tanks. One inch of lithium in the dump tank is equivalent to about nine inches in the surge tank. Make the final calibration of the new probe by comparing the probe output during a stringer servicing to the level of lithium seen on the fisher rod (level below the top of surge tank is about 0.5-1 inch less than the length of fisher rod (top) not wet by lithium.) Remember to compare the fisher rod to the probe output measured at the time the fisher was in the test section.

The probe output at the bottom of the probe (about 14" down) can always be checked by slowly draining the surge tank and noting the probe reading just before the reading goes offscale. The high level output also be checked by noting the reading when the standpipes have just frozen, and, after waiting some time to assure the lithium plugs are well formed, lowering a fisher rod carefully into standpipe and checking the level of the frozen lithium surface.

Whenever the lithium level is lowered near the bottom of the surge tank, be careful not to completely drain the tank and get an argon bubble into the economizer. Also NOTE that the standpipe flanges are 2- 2.5 inches below the top of the surge tank and will overflow sooner than the surge tank.

When the 30" long lower fisher rod and the 17.5" stringer (47.5" total) are all the way into the test section (which is 44.5" from stringer stop to standpipe flange) 3" of the fisher rod are above the flange. Therefore, the distance of the lithium below the flange is the unwet length of the fisher, minus 3".

Replacement level probes should have a 1/8" diameter, series 300 stainless steel wire electrode (appropriate resistance for the constant current source used and for the 50mv range of the level monitor. The probe body should be a vacuum pass-through or a spark plug, welded onto a 1/2" stainless tube 3" long. A vacuum passthrough fitting is simpler to use, requiring minimal machining and only a button weld. The fitting may be weaker against thermal shock (one leaked through the ceramic-metal joint after lithium apparently splashed against the inside of the probe) and the vacuum fitting may also be less sturdy against mechanically rough treatment than a probe made from a spark plug.

The spark plug type probe may be sturdier and its hexagonal casing makes it easy to turn (which may help free a stuck, broken probe). The hexagonal body may obstruct the swagelock nut below it, however. The spark plug should have no internal resistor or capacitance; the resistance of the level probe must be mainly in the stainless steel electrode wire. (Additional resistance introduces an offset in the probe output which makes it harder to monitor on a recording instrument, although in an emergency the probe signal could be offset by a potentiometer to bring it into the recorder's range.) If a spark plug is used, the outer electrode bar must be ground off and the threads on the plug may have to be turned down to facilitate welding it onto the 1/2" stainless tube. Before putting the finished probe into the surge tank, the Swagelok ferrules should be seated onto the 1/2" tube 1" from the bottom. This will assure that 1/2" or so of the tube protrudes below the inside of the surge tank lid. This short extension of the tube into the tank is thought to help prevent lithium from wicking from the lid onto the central electrode wire of the level probe.

<u>Removing a trapped gas bubble</u> (from the economizer or radiator, in general): In November 1979 a gas (argon) bubble was accidentally trapped in the loop (apparently in the economizer or radiator. This seemed to have occurred during an evacuation and backfilling of the surge tank or the standpipes. The freeze plugs had been assumed to be solid, but one was apparently melted, and pressure imbalances forced lithium up the standpipe and into the ball valve area. At this time or in subsequent vacuum/backfill operations a bubble must have been admitted into the economizer.) [7-152; 6-25ff]

After assuring that the freeze plugs were all frozen, the surge tank was drained partly and a partial vacuum was applied there, causing the trapped gas bubble to expand and drive lithium into the surge tank, raising the level there. The volume of the trapped gas was large enough to prevent application of a good vacuum to the surge tank without overflowing the tank. It thus would not be possible to effectively refresh the argon in the loop after stringer servicing, meaning that some of the air which diffused into the standpipes and surge tank during the servicing could not be removed. The trapped bubble itself must therefore be removed, at least in part.

The volume of the gas bubble at atmospheric pressure (volume $V°$) was calculated using the ideal gas law, simplified to the form

$$14.7\text{psia}\ V° = P' (V° + \pi R^2 \Delta h)$$

where P' is the absolute pressure of a partial vacuum applied at the surge tank, R is the inside radius of the surge tank (2.13") and Δh is the increase in the lithium level in the surge tank when the partial vacuum is applied. (Start with only 3-4" in tank.)

The volume of the trapped gas was thus estimated to be about 60 in^3 at atmospheric pressure. It was not possible to pull much of a vacuum at the surge tank without bringing the lithium nearly to overflow the tank. The following procedure was used to reduce the size of the trapped gas bubble. (Appendix G; [7-152; 6-25ff])

1. The test sections were frozen by turning off the heat to the meter sections and the isothermal oven. This assured that all lithium admitted to the loop (from the dump tank) through the lower drain valve would have to come to the surge tank via the outer pipe of the economizer.

2. The surge tank was drained by gravity or by applying a slight positive pressure to the surge tank. The upper drain valve was used. (The radiator must be thawed.) The surge tank was not completely drained, since this would only let more gas into the economizer.

3. The surge tank level was raised about 9" (from 2" to 11" full) by pressure filling (about 1" of lithium from dump tank @ 3-4psig) through the lower drain valve. This assured that lithium flowed up through the outside pipe of the economizer, filling it.

4. Steps 2 and 3 were repeated 4 more times. This meant that a total of about 450 in^3 of lithium was filled into the outer pipe of the economizer (some of it running into the radiator, inside pipe of the economizer, and down to the surge tank). Since the outer pipe of the economizer was not allowed to drain (all draining was

from the surge tank, via the inner pipe of the economizer, and out through the upper drain valve) there could not be any gas bubble left in the outer pipe of the economizer. (Actually, repeating steps 2 and 3 so many times is not necessary if the volume of trapped gas is well known; only that volume of lithium (V°) need be filled through the outer pipe to assure that it is free of gas. The total volume of the surge tank is about 180 in^3, the economizer volume is about 500 in^3. 9" in surge tank = 100 in^3; 1" dump = 120 in^3)

5. The electromagnetic pump piping and cell were frozen to seal the lithium in the outer economizer pipe. The meter sections and isothermal oven sections were then carefully thawed. Subsequent operations would concentrate on reducing the size of the gas bubble in the radiator and inner pipe of the economizer.

6. The induction-type level probe must be used to measure the level of lithium in the dump tank, since during much of the procedure the surge tank would be empty and the level probe there useless. The surge tank (volume about 180 in^3) will hold the equivalent of about 1.5 inches of lithium in the dump tank (where 1" change of level means 120 in^3 of lithium). (Probe instructions: MSAR 1973.)

7. Drain the surge tank through the lower drain valve. When the level probe goes offscale, note the dump tank level and then drain more lithium so that the dump level rises one half inch more (but not above about 11"; the dump tank lid is at 13"). Use a liquid-nitrogen cold-trapped roughing vacuum pump to vacuum the dump tank. Maintain the vacuum but do not have the pump valved into the tank

while the drain valve is open (for safety, minimize the number of valves left open at one time.)

8. Now vacuum the surge tank carefully and slowly until the lithium rises back into the tank and turns on the level probe giving either a continuous steady signal or a jumping signal, indicating lithium is being splattered into the tank by gas bubbles escaping from the economizer. Do not allow the surge tank to fill any farther, as splashing lithium may hit the top of the probe, causing it to short and / or leak (both a short and a leak through the ceramic insulator were experienced in the November 1979 operations.) If the lithium continues to rise into the surge tank after the vacuum has been valved off, increase the pressure in the surge tank by quickly adding argon.

9. Repeat 7 and 8, gradually reducing the pressure in the surge tank to the best vacuum the (second) liquid nitrogen cold-trapped pump there can attain. As the pressure on the surge tank is lowered the trapped gas bubble will expand and eventually will completely fill the inside pipe of the economizer. Further reduction in the surge tank pressure should cause no more lithium to rise into the tank. The vacuum valve and surge tank valve can then be gradually opened wide to maximize the vacuum pumping efficiency. Vacuum with wide-open gas valves (vacuum port and surge tank gas valves) for one half hour.

10. Stay within an arm's reach of the surge and vacuum valves. If you must leave the surge tank, close the surge tank valve but maintain the best possible vacuum on the gas manifold, since any leaks in the manifold will quickly degrade the vacuum. (It is a good idea, before attempting the gas bubble removal at all, to completely recheck the leak-tightness of the upper manifold).

It is important that the radiator be quite hot during the gas bubble removal process, since frozen zones anywhere might hold back entrapped gases which could burst during the vacuuming, causing the surge tank to overflow,shorting or breaking a probe, or worse.

11. After vacuuming the loop for half an hour or more, close the surge tank gas valve. Pressurize the dump tank with argon. (For maximum safety, the dump pressure can be about 2-3 psia <u>greater</u> than the loop (surge tank) pressure; for convenience it might be simply 3 psig, but more care must be taken to prevent overfilling the loop).

12. Fill lithium slowly into the loop, watching the dump tank level indicator to gauge the amount until the surge tank level probe is activated. First fill at least .5" (dump tank)through the upper drain valve to ensure the radiator is completely full of lithium. Then fill through the lower drain valve. During this filling--which should be done slowly--maintain the vacuum on the surge tank to take advantage of the compression of the gas bubble by the lithium to aid in removing more of the gas. Two people should be present,

one at the surge tank and one at the dump tank/drain valves. When the lithium reaches the surge tank, close the surge tank valve and allow the lithium to fill the surge tank about half full. (8-10" of lithium in the surge tank, or about 2/3" of lithium transferred out of the dump tank after the surge tank level probe comes on. However, since the economizer fills simultaneously with the surge tank, 2/3" of lithium from the dump tank may not fill the surge tank this much. The 8-10" level is safe in the surge tank.)

13. With the surge tank valve shut, vacuum the upper manifold to remove any air that may have leaked in. Then, bleed argon into the manifold until the pressure there is only 5" Hg above the pressure in the surge tank. This small volume or "shot" of argon in the manifold is then bled into the surge tank (keep the manifold argon supply valve shut now). The lithium level in the surge tank will go down as the argon bleeds in. It should take 10 "shots" or more to push the lithium level to about 3" in the surge tank (or just until the probe looses contact with the lithium.) Record the level and pressure after each "shot" of argon. When the tank is almost empty (3" left or no probe contact) close the surge tank valve.

Do not allow the lithium level in the surge tank to fall below where it just breaks contact with the probe. There will then be a 2" safety margin before argon can get out of the tank and back into the economizer again.

14. Fill some more lithium into the loop (as in step 12) until the level in the surge tank is again 8-10" (half full).

15. Repeat steps 13 and 14 until the surge tank pressure is about 1 psig (it may be necessary to increase the pressure in the dump tank slightly toward the end of this) and the surge tank is about half to 2/3 full. The addition of argon to the surge tank by little "shots" is a slow, effectively controllable way to increase the pressure of the loop, so use this method.

16. When the gas bubble has been reduced by the above steps, recheck the bubble volume V° (with the method given earlier). The volume should be reduced so that a vacuum to about 2" Hg absolute pressure does not overfill the surge tank. By vacuuming to this pressure and backfilling several times, a rather high purity argon can be maintained in the loop.

The volume of the gas bubble may be further reduced by using a better vacuum pump and / or making sure the gas manifold is leak-tight. After long term operation at a fairly high temperature, the sealants used on the manifold joints may degrade.

The process outlined above may take several hours. Make sure the liquid nitrogen cold traps are kept full during this time. Have a good supply of LN_2 for replenishing the cold traps.

As an alternative to steps 2, 3, and 4 above, with lithium frozen in the test sections and radiator, vacuum the outer pipe of the economizer through the dump tank and upper drain valve, then fill the outer pipe from a pressurized dump tank through the lower drain valve. Doing this several times should fill most of the outer pipe.

Extremely difficult repairs

Service radiator housing: Radiator itself (finned pipes) is an integral part of the loop and cannot be removed without breaking piping welds. The finned pipes are supported by the sheet-metal ends of the radiator housing. The ends of the housing are bolted onto the steel angle ribs of the housing. The ribs support the front and back sheet metal and are bolted to the radiator struts which finally are bolted to the frame of the enclosure.

Note first that removal of any part of the radiator housing is not recommended. The back has many thermocouples coming through it, as well as the electrical power wires for the internal heaters. All of these would have to be cut to remove the back housing; insulation would have to be removed and the back would have to be lifted down between the economizer and the finned-pipes. The main reason against removal of the rear housing, however, is that it holds the housing end pieces, which in turn hold the finned piping. Taking away any of this support even temporarily would risk straining the finned pipes severely. The entire assembly is rather heavy and unwieldy and has not been taken apart since the piping members were welded into the loop.

Even removal of the front housing would likely strain the finned pipes since the housing would lose some of its rigidity. The front housing can only be removed upward after taking off the enclosure roof .

The lower duct leading from the blower into the radiator can be more easily removed. Take off the middle rear enclosure panel. Unbolt the lower duct from the bottom of the radiator housing in the front and back and drop the duct down between the radiator struts.

The upper duct (atop the enclosure, leading to the filter box in the duct to the ceiling fan) is very heavy and extremely difficult to handle. It had to be worked into place between the radiator and the exhaust ductwork above. Tabs or flaps on the bottom and top of the duct fit into the radiator housing and the uppermost ductwork. Bolts secure the duct to the housing and "pop" rivets (#30 drill size) fasten it to the exhaust ducting. After unfastening these, the duct would have to be lifted 2", clearing tabs from the radiator, then shifted forward and then down to clear its flaps from the exhaust duct. Finally the assembly must be lifted up and out of the loop enclosure, without dropping it down on anything inside. The duct is heavy (#16 gauge) sheet steel and weighs upwards of 100 pounds.

Replace tubular heaters: Turn off the power to and disconnect the heater. The affected piping must be frozen for safety. Disconnect the thermocouple splices in the area. Remove the piping insulation carefully. Parts with hangers must be supported by other means while the heaters are removed. Loosen and remove the hangers. Remove shim stock, wire ties, and clamps holding the defective heater. Look closely for holes in the heater or piping. If the heater has arced, it may have damaged the pipe wall. If so, get advice about repairs to the pipe. (For example, see Mausteller, 1967).

Remove the tubular heater and replace it with a 0.247" incoloy-sheath tubular heater of approximately the same length and rated for the same power at a maximum of 240 volts. The replacement should be formed into the same shape as the original, which may be used as a model.

Refer to the manufacturer's suggested method of bending tubular heaters. The inside diameter of the bend must not be less than 1/2" for a 1/4" heater. A tool is available or can be made easily to facilitate bending the heaters. Use a small magnet to locate the end of the terminal pin where the threaded end of the heater connects the internal resistance element. Do not bend on or within an inch of the terminal pin. Generally the pin extends several inches inside the incoloy sheath. (General Electric; Wiegand catalogs.)

Clamp and wire-tie the heater onto the pipe at the points where the original heater was fastened. Wire-ties should be stainless steel or nichrome, 0.06 inch in diameter, doubled, twisted tightly until just a turn or so before breaking. The breaking point can be experimentally determined with a few tests.

Snap the shim stock back onto the pipe, and replace the hangers and tighten the hanger springs lightly. Replace the insulation on the pipes. Reconnect the thermocouples and hook up the heater terminals. Glass-tape all connections with Scotch #27 tape.

Remelt the repaired section with careful heating, starting with a low heat to prevent pipe rupture during the thaw.

Replace isothermal section strip heaters: Remove the isobox extension panel to replace outer (left end) heaters. Turn off the heaters and disconnect the 6 heater wires. Remove the insulation batts, exposing the heater plate. If necessary, unbolt the heater plate at the sides of the isobox. Pull it out. Replace the strip heater(s). Refasten the power lead-throughs (stiff stainless steel wires through ceramic insulators) and put the two insulation batts back on. Reconnect the heater wires; replace the isobox extension panel.

To replace inner (right) isobox heaters, remove the back panel nearest the test section. (It may be necessary to remove the thermocouple junction box first.) Remove insulation as needed from isobox. Proceed as with the outer heaters. Note that the inner heater plate is not removable from the rest of the isothermal oven; it is welded together with the box. It may be necessary to use sheet metal screws to fasten replacement heaters to this side of the isobox. The nuts holding the fastening bolts may be welded to the inside of the isobox, in which case bolts may be used again; otherwise screws are necessary. The next page describes how to remove the isothermal oven completely from the loop.

Remove isothermal oven: Turn off pump. Freeze the entire test sections for safety. (This must be done with care to avoid stressing the test sections. Two operators should work on this project.)

Remove the back enclosure panel nearest the test sections. and the isothermal box extension at the left end of the loop. Disconnect the right heater wires and remove the insulation at the right of the isobox (toward the interior of the loop). Disconnect the left (out)side heater wires. Remove two batts of insulation at the left heater plate. Unscrew bolts on sides of isobox to release the left heater plate. Remove the plate by pulling it outward. Remove two more batts of insulation to expose the four test section pipes. Thermocouples on these pipes will be very fragile after their prolonged exposure at high temperatures.

Loosen the 1/4"-20 nuts holding the isobox to the square band and isobox struts. Loosen the 3/8"-16 nuts holding the struts to the enclosure frame. Drop or lift the struts to release isobox; catch it before it falls inward onto the meters.

Remove electromagnetic pump: Disconnect the shipping tank and move it. The transfer tubing may also have to be removed (between the shipping tank and dump tanks). Insulation and possibly clamshell heaters may have to be removed from main heater.

Remove roof of enclosure in front of radiator. (It is assumed that the pump, main heaters, etc. which are in vicinity are turned off.) Pump cell heater tapes should be disconnected. Remove cell insulation and unwrap heater tape. Unbolt the cell electrode straps. Place a 5 or 6 foot long heavy (1" Sc 40) steel pipe over the loop roof opening, resting on the enclosure frame. Hang a hoist from this pipe. Remove insulation (from radiator and economizer) to allow the hoist hook to be put through the eye-bolt on the pump. Secure the pump to the hook with a heavy duty rope in case the eye-bolt breaks loose. Loosen and remove the four 3/8"-16 bolts holding pump to its table. Carefully shift the pump down the table to the right. At all times tension should be kept on the hoist in order to support most of the weight of the pump. Use extreme caution; do not stress the pump cell. When the laminated steel poles of the pump clear the nickel electrodes of the pump cell, push the pump back to disengage it from the pump cell. Lift the pump slightly to get it off the table, and move the hoist to the right by inching the top hoist hook along the pipe which holds it athwart the roof frame. Lower the pump down between the radiator and main heater and dump tank. While lowering the pump or raising it, keep some support close below it to stop its fall if the hoist breaks or slips. When the pump is on the floor, remove it through the back of the loop under the radiator duct.

Remember that the pump is very heavy. If it should drop--on pump piping, heater, dump tank, or even floor, or if it swings and bangs into pump cell or pipe--very serious and dangerous damage could result.

APPENDIX K. EQUIPMENT SUPPLIERS

SUPPLIERS

Asbestos Service Co. 6510 River Parkway Milwaukee, Wis 53213 (414) 453-0535	Marinet brick for main heater (not used)	2/13/76
Arneson & Company 7701 Normandale, South Minneapolis, Minn 55435	Constant current source for continuous level probe	10/19/77
Badger Valve & Tube 1504 Underwood Street Wauwautosa, Wis 53213 (414) 774-0552	Swagelock fittings, Whitey valves	
Badger Welding Supplies 101 S. Dickinson Madison, Wis 53703 257-5606	Chrome Leather Clothing Argon	4/76
Cathodic Engineering Hattiesburg, Miss 39401	Loresco brand graphite spheroids type DW-1	2/4/76
Central Steel & Wire Co. 3000 W. 51st Street P.O. Box 5310A Chicago, Ill 60680 (312) 471-4000	Stainless steel wire .062;.05" bright soft temper wire	2/18/76
Century Hardware P.O. Box 1999 Milwaukee, Wis 53201	Ladder WLS1-8ft wooden, straight ladder	8/17/78
W. Classmann Corp. 2014 W. Bender Road Milwaukee, Wis 53209	HEPA filter and supplies	10/26/76
Cordon Company 2322 W. Clyborn St. P.O. Box 291 Milwaukee, Wis 53201	Ball valve parts for Worcester valves	10/79

SUPPLIERS (CONTINUED)

Culver Electric 637 E. Washington Ave Madison, Wisconsin 43703 255-6756	Relays for heaters	3/76
EDI Electronics Distributors 4900 N. Elston Ave. Chicago,Ill 60630 (312) 283-4800	Dimmers, phone plugs, phone jacks	12/77,8/78
Norman Erway,Glassblowing Stoughton, Wisconsin	Modified Vacuum stopcock for Kjeldahl	4/79
Fluke Midwestern Tech Cntr 1400 Hicks Road Rolling Meadows, Ill 60008 (312) 398-5800	Digital thermometer (service)	10/9/78
John Fluke Company 10800 Lyndale Ave. South Minneapolis, Minn 55420	Digital thermometer #2160A/K	
General Electric Co Shelbyville, Indiana	Calrod brand tubular heaters	1976
Gordon Engineering 1882 E. Main Madison, Wis 53704 244-6292	Miscellaneous hardware, Stainless steel shim stock	
Gordon Hatch Co., Inc 6635 South 28th Street Milwaukee, Wis 53215	Chromalox brand tubular and strip heaters	2/78
W.W. Grainger, Inc. 501 Atlas Avenue Madison, Wis 53714 221-3861	Dayton brand #2C739 blower and motor #2n996 NEMA 184 frame continuous duty, 3ø	8/12/76
Graphic Controls Corp. Recording Chart Div. 189 Van Rensselaer St. Buffalo, New York 14210	Chart paper for recorders 0-2000F type K-#552 0-10 mv #5401	1/30/76

SUPPLIERS (CONTINUED)

Graybar Electric 1301 W. Badger Road Madison, Wis 53713 255-0005	Type SF-2 Heater wire Hoffman box A202406LP for heater terminals	4/22/76 1/28/77
Hoffman Chemical & Supply 1206 Ann Street Madison, Wis 53713 256-5403	Ansul brand Metl-X fire extinguishant Lavoptik eye wash	8/3/78 10/6/78
Leeds & Northrup North Wales, Penn 19454	Thermocouple wire Type K glass/glass #858006 (20-58-23) PVC extension #859017 (16-59-16) fish spine insulator beads #34365	1976
Newark Electronics 500 N. Pulaski Chicago, Ill 60624	Relays for dimmer heating circuits. Electronics for smoke alarm. SCR for radiator controller	3/19/76 2/76 9/79
Omega Engineering Box 4047 Stamford, Conn 06907	Omega brand temperature controller for radiator	5/79
Research Organic/Inorganic 11686 Sheldon Street Sun Valley, Calif 91352 (213) 877-5631	Titanium and zirconium foil for hot trapping lithium	1/20/76 1/11/77
Scientific Products 1210 Waukegan Road McGaw Park, Ill 60085	Briskeat brand heating tapes, heavy insulation Samox type (800C)	10/20/78
Tubesales 5544 St. Charles Road Berkeley, Ill 60163	Stainless steel type 316 and 304, including coupon tubing	Frequently; 10/20/78
Thermocraft	RH256 clamshell heaters; 3"ID, 4"OD. 1730W @ 220Volts.	8/1/75

SUPPLIERS (CONTINUED)

Ventron/Alfa Division 152 Andover Street Danvers, Mass 01923	Glove bags	
Viking Glass 1025 W. Main Stoughton, Wis 873-9401	Glass for enclosure window	10/30/77
Federal Property Program 201 S. Dickinson Madison, Wisconsin 266-0942/1561	Government surplus equipment including ammeters, fuseholders hanger springs	
Physical Science Lab 3725 Schneider Road Stoughton, Wis	Contractor for most of construction; assistance and ordering of most supplies. THANKS!	

APPENDIX L. STRINGER SERVICING

EQUIPMENT AND PROCEDURES

Stainless steel stringer and coupon system. [3-53,117ff;5-46]*
See Figure L.1

Piping parts:

A. Puller pipe. Tape heated with 1" x 4', High temperature Samox insulated 576 Watt/120 volt heater, rated for operation on bare metal workpiece at 800C. Removable 46" long, 3/4" Schedule 40 pipe threads into top ball valve on test section to hold the parts I and II which will be coated with lithium. Contains stringer, shroud, sleeve, and lower fisher rod during preheating;before/after removal/replacement. Puller pipe is not leak-tight.

B. Adapter pipe. Trace heated. About 12 inches long overall. 3/4" schedule 40 non-stainless steel pipe sealed at top and bottom by ball valves. Pairs of adapter pipes #1,#2 and #3,#4 are joined through stainless steel "gooseneck" gas tubing which leads to a valved connection into the upper gas manifold. This allows vacuum or argon connections into adapter pipes and from there into the standpipes or puller pipes. Adapter pipe can be removed from standpipe by unbolting the lower ball valve when the freeze plugs of lithium are formed in the standpipes. (Note:puller pipe can't be vacuumed.)

C. Standpipe. Trace heated. 21 inches long; 1/2" Sc 40 stainless steel integral to lithium loop. Flange welded on top fits to lower ball valve. Lithium is allowed to freeze inside the standpipe to seal the test section during normal (pumped flow) operation. Freeze plug is melted in order to put fisher rod and stringer through the standpipe.

D. Test section isothermal zone. Oven-heated. 5/8" OD by .049" wall thickness tubing. Stringer is seated in this tubing during flow operation. An approximately 2" long adapter tee joins the test section tube to the standpipe above it. The test section has a stop welded inside it 21-1/2" below the adapter. The test section joins the meter section upstream of it through a 90 degree bend with a 6" radius. The internal stop in the test section is about 7" above the plane of the meter sections.

* additional notebook references [1-88; 3-8,142; 4-26; 7-93]

Stainless steel stringer and coupon system.
See Figure L.1

Stringer and fisher parts:

I. Stringer. Split-tube 17.5 inches long. 1/2 " OD x 0.083" wall thickness. Holds series of 16 coupons, each 5/16" OD x 0.035" wall x 1.00" long. Stringer is tied shut by 6 stainless steel wires 0.02" in diameter in recessed grooves. Slotted bottom of stringer engages a stop in test section (part D) and threaded top receives part II, the lowermost fisher rod. Threads are 3/8"-24.

II. Lowermost fisher (or puller) rod. Stainless steel 3/8" rod, about 30" long. Threaded nose engages part I. Nose end is 3/16" in diameter. The threads are 3/8"-24. Nose is drilled out with a 3/32 inch drain hole terminating in a radial hole at the top of the threads. This hole allows lithium to flow out of the stringer when the stringer is pulled out of the lithium. A 1/8 inch pin, welded in place, diametrically through the fisher just above the threads, extends out about 1/16" on both sides to catch top of shroud, part a. Top of fisher rod is drilled and tapped to accept the bottom of the next higher fisher. Lithium never touches the top 5 or 6 inches of fisher rod II. [3-137]

III. Middle fisher rod. Mild steel 3/8" rod 34 inches long. Nose end 1" long: 1/2" of 1/4"-20 threads to engage top of lower fisher; bottom of this piece is 1/2" long pilot with diameter just undersize of #7 (.19") drill, which was used to make pilot hole in top of lower fisher. Parts II and III were screwed together and a tap hole was drilled diametrically through both so that it pierced the nose-end of part III. The two parts were unscrewed and the nose end of III was tapped by a #4-40 tap. The matching hole in the top of part II was drilled out to pass a #4-40 set screw. The setscrew is 3/8" long.

IV. Top fisher rod. Same material as part III. Length is 32.5" . In all other respects III and IV are identical.

Parts II, III, and IV have flats machined across the tops about 1" from the end to aid in gripping with a wrench. In the flat is drilled a 9/64" diametral hole x for safety cotter pin to prevent accidental dropping of the fisher into the test section. Parts III and IV also have a safety hole drilled through them halfway along their length, to aid in removing sleeve (part c) or for a safety stop just before the fisher/stringer bottoms out in test section D.

Stainless steel stringer and coupon system.
See Figure L.1

Shroud and sleeve parts:

a. Shroud. Overall length about 19.25"; bottom thin-wall part is 10.5"long and extends through both ball valves to protect them from lithium on the fisher (II) and stringer (I).* The lower end is 9/16" OD x 0.01" wall thickness. The heavier upper part is 5/8" OD with an 0.035" wall thickness and serves to increase the total length of the shroud so that it will encase the stringer I. The inside length of the shroud is about 18.25", which will hold the stringer and the part of the fisher rod II below the diametric pin. The shroud parts are welded together. The plug at the top of the shroud is drilled out to pass the 3/8" fisher but not the diametral pin in the lower end of the fisher II. Hence, the shroud is carried upward on the fisher once the fisher clears the adapter pipe B.

b. Sleeve. 1/2" outside diameter stainless steel tube with a wall thickness of about 0.035"; 26.2" long. Fits over fisher rods and is used to push shroud a through ball valves.

c. Sleeve extension. Same material as sleeve b.
Sleeve must total about 40 inches long but cannot be in one piece or the fishers would be difficult to assemble.

d. Spacer. Approximately 3" long. The spacer is used because the puller pipe itself is not long enough to contain the total length of the combined fisher and stringer (parts I and II). With the spacer added, a cotter pin through the top of the fisher (II) will hold the stringer completely inside the puller pipe so that the pipe can be screwed onto the ball valve (top of part B) or so that the pipe can be capped.

* Note the holes designated "y" in the shroud. These allow some limited movement of gas (argon usually) through the shroud when it is positioned in the ball valves; the close fit of the shroud in the valves would restrict gas flow (and pressure equalization). The holes were originally made with the intention of using an argon purge during the fishing (removal or replacement of stringers) operation, but a purge at this time seemed to cause instability in the lithium levels in the surge tank and standpipe. The holes also help somewhat to hasten the dissolution of lithium inside the shroud during its cleaning.

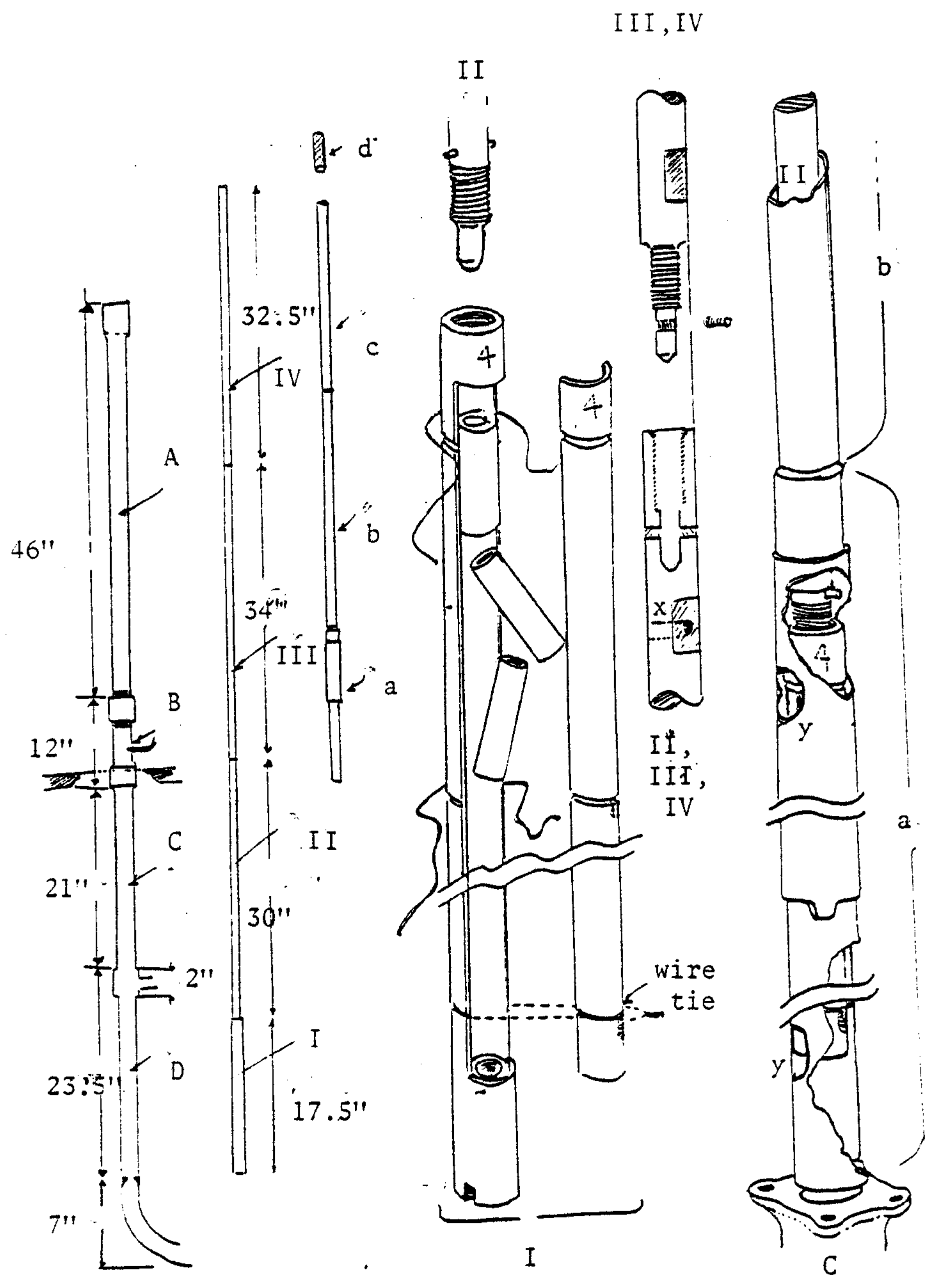
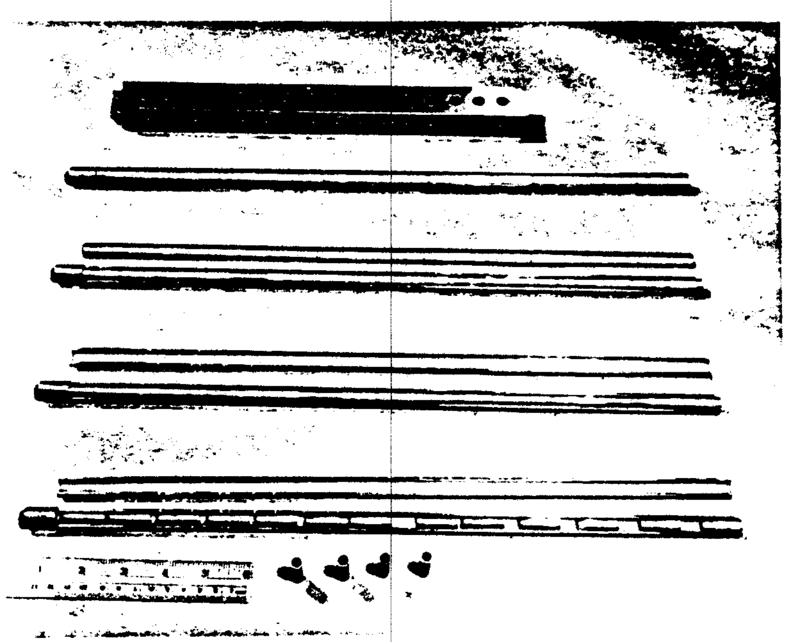


FIGURE L.1 TEST SECTION AND STRINGER SYSTEM



STRINGERS AND COUPONS IN VARIOUS STAGES OF ASSEMBLY
FIXTURE IS FOR MACHINE GRINDING COUPONS TO LENGTH

Stringer servicing

Stainless steel stringers with coupons are removed from the loop approximately once a month. The stringer servicing operation, as it will be called, or more simply, the "pull", typically takes two days. On the first day the stringers are removed and the coupons cleaned; on the second day, the coupons are weighed, put back into the stringers, and the stringers replaced back into the test sections. The procedures given below are suggested.

I. First day; 8 a.m.

A. When arriving at lab:

1. If necessary restrict air flow through radiator by closing blower gate, damper, and/or reducing airflow through lab. If radiator was operating around 250C this will heat it somewhat in preparation for cessation of lithium flow operation.

2. Turn on oven in laboratory 1406 at setting 12; 170C. Oven will be used to dry stringer shrouds and sleeves.

B. Adjust heaters.

1. Take precautions against shock while rewiring heaters.

a. Remove fuses (control board) from circuits JK, LM, NO, PQ, RS, TU; or turn their control devices down so that their ammeters read zero. This prevents arcing of switches in next step.

b. In heater terminal box, flip all six switches to center-off positions to disconnect 208 volt power from terminal strips.

c. Turn off any dimmers (usually D54 and/or D58) serving radiator, and any other devices powering radiator heaters.

I. B. 2. Rewire radiator heater connections in terminal box from normal operation to standby operation.

a. Loosen terminal screws holding fanning strip to radiator terminal barrier strip. Remove this "normal" fanning strip, taking care not to short it across the adjacent terminal strips.

b. Put "standby" fanning strip on radiator terminal barrier strip and tighten terminal screws.

c. Connect dimmer DS4 to radiator heater #87. Move the extension wire pair for circuit JK from its parking position on an unused pair of screws. Attach JK to radiator heater terminals #82.

d. Flip terminal box switches to positions given in Table L.1 to connect the 208 volt circuits to the appropriate heaters.

e. Replace fuses removed in step I.B.1.a. (JK,LM...TU)

f. Set heater controls as directed in Table L.1 for standby operation. Where a range of values is given, use the lower power setting. Adjust up or down as needed.

C. Prepare to stop flow of lithium. Temperature of test section is dropping slowly and temperature of radiator climbing.

1. Phone University Police (262-2957; business number 262-4524) and notify the alarm board operator that alarm from lithium loop will go off during next few hours. This normally occurs when the lithium level is lowered in surge tank, but sometimes also happens if residual heat in the main heater brings its temperature above the limit setpoint on the overtemperature switch.

2. Put 208 volt heaters on manual mode.

a. Depress manual enable switch on control board and hold this spring switch shut with special "key."

b. Remove blocking bar from auto/manual switch and flip switch to change 208 volt control to manual.

c. Try to be in laboratory when the heaters are on manual mode since the automatic shutoff is inoperative.

TABLE L.1 (continued next page)

TRACE HEATERS

Dimmer number	Heater	Normal setting*	Standby setting*
45	Pump Cell Tape	35	48
48	Top Manifold	34	45
51,52	Top, Middle Isobox	50	60-70
53	Bottom Isobox	60	60-80
54	Radiator Right U-bend	(disconnected)	full voltage**
56	Right End & Cold Trap	36	40-50
58	Puller Pipe Tapes	16(heater #91)	25
60	Dump Valves	7	full voltage

* Dimmer settings given as reading of ammeter. Ammeter full scale reading is "80" when amperage is 5 amperes.

** Dimmer full voltage is 120 volts when the dimmer dial is fully clockwise, irregardless of ammeter reading.

TABLE L.1 (continued)

208 VOLT HEATERS--NORMAL SETTINGS FOR PUMPED FLOW OPERATION

Adjust settings to maintain desired test conditions

Controller JK	to	Two Main Clamshells	at	Automatic Control
Transformer LM	to	One Main Clamshell	at	200-220V for ΔT=200C* off for ΔT=100C
Transformer NO&PQ	to	Two (NO) Clamshells	at	70-80% for ΔT=200C 70-80% for ΔT=100C
		One (PQ) Clamshell	at	70-80% for ΔT=200 off for ΔT=100C
Transformer RS	to	Radiator Heaters (#83,84,85),(81-87)**	at	50-70%
Controller TU	to	Radiator Heater #86	at	Automatic Control on radiator outlet pipe -lithium minimum temp.

208 VOLT HEATERS--STANDBY SETTINGS DURING STRINGER SERVICING

Use higher settings only just before restarting loop

Controller JK	to	Radiator Heaters (81,82,83) careful!	at	Manual: 50-100% Don't overheat #81, left U-bends.
Transformer LM	spare			
Transformer NO&PQ	to	Two (NO) Clamshells	at	10-25% careful!
		One (PQ) Clamshell	off	
Transformer RS	to	Radiator Heaters (84,85)	at	60-95%
Controller TU	to	Radiator Heater #86	at	Automatic Control on radiator lower fin pipe 450-550C set point

* ΔT is the temperature difference between loop maximum and minimum lithium temperatures.

** (83,84,85),(81-87) notation: comma is parallel wiring and dashes are series wiring.

I. D. Stop electromagnetic pump.

1. Unplug servo motor attached to pump control handwheel.

2. Trip pump control switch to turn pump off.

3. Warning buzzer on flowmeter recorder will sound to warn of low flow rate (in this case, no flowrate.)

4. Open the flowmeter recorder door. Swing out the chart carriage. Pull the mercury (capsule-type) switch from the clip on the drive wheel behind the chart. Set the mercury switch inside the recorder, in a position so that the switch opens and the buzzer is silenced.

At this point a localized freezing may occur in the radiator (at least if it was running at around 250-300 C.) Presumably freezing first happens in the U-bends which are in effect heat-sinked to the radiator housing. It may be impossible to restart lithium flow now although the thermocouples read well above the melting point of lithium, since some of the coolest parts of the radiator are not fitted with thermocouples.

NOTE ON THE FOLLOWING PROCEDURES: It is not advisable to use vacuum or differential pressure on the surge tank or standpipes if any standpipe ball valve is plugged, since gas trapped under the valve may end up in the economizer, or may bubble up causing additional plugged valves or shorted level probes.

E. Refresh the argon cover in the standpipes (mandatory) and in the surge tank (necessary only if <u>any</u> standpipe is thawed, so that the surge tank must be included to ensure pressure equalization). If the surge tank is not included:
1. do not open its valve in the following procedure, and
2. surge tank level should not change <u>at all</u>.

1. Fill dewar cold trap with liquid nitrogen,

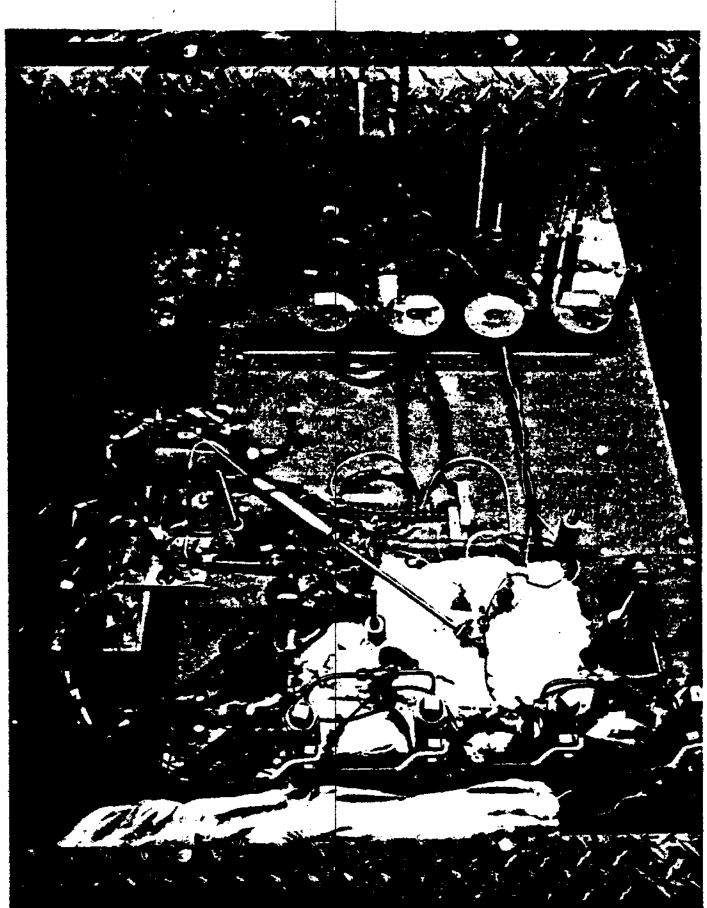
2. Set argon delivery pressure at .1 psig.

3. Attach cold trap hose to vacuum port on back of top gas manifold. Make sure that the vacuum port valve on the manifold is shut tightly.

4. Attach other side of cold trap to vacuum pump.

5. Shut all ball valves and gas valves on top of loop.

6. Put cold trap into dewar and turn vacuum pump on.



TOP OF LOOP ENCLOSURE, SHOWING BALL VALVES OVER EACH TEST SECTION; ALSO GAS MANIFOLD AND VALVES, SURGE TANK WITH DEMISTER, THERMOCOUPLE CONNECTOR BOX, AND FLOW CONTROL VALVE WHEELS. SPRING-LOADED BOLTS SUPPORT LOOP INSIDE ENCLOSURE. RADIATOR AND ENCLOSURE DUCTS ARE IN BACKGROUND.

I. E. 7. Open these valves carefully:

a. Surge tank gas valve.*(but see above)
b. (Two) gas valves connecting manifold to adapter pipes.
c. (Four) lower ball valves. Open with special care. Top ball valves must be closed during these operations. Level of the lithium in surge tank should not change when the ball valves are opened.

8. Maintain watch on the continuous level indicator.

9. Carefully crack open vacuum valve. Level should not change. If it does, recheck that all top ball valves are closed. Open vacuum valve only slightly at first.

10. Vacuum slowly to reduce the pressure over the surge tank and standpipes to a fairly good vacuum; 27" Hg reading on the manifold gauge. This should take a couple of minutes and the lithium level in the surge tank should be steady.

11. Near a vacuum gauge reading of about 26-27" Hg, the level indicator may creep downscale about 1 millivolt. This indicates an increase of about 1/2" in lithium level in the surge tank and might be due to expansion of gases entrapped in the economizer.*

12. When upper manifold (and surge tank and standpipe) reach 26-27" Hg vacuum reading on gauge, close the vacuum valve.

13. Immediately, with care, crack open the argon supply valve on the manifold. The continuous level indicator will shift upscale slightly as the entrapped gases are compressed in loop, dropping the level of lithium in the surge tank. The p-gauge will not change immediately; the level seems more sensitive to changes in pressure at very low absolute pressures, than does the gauge. Take about 1 minute to restore the argon pressure to a positive pressure of 1 psi gauge. Close argon valve.

14. Close valves: First lower ball valves, then gas valves between manifold and adapter pipes, and finally surge tank gas valve.

WARNING: Never open upper ball valves while vacuuming loop. Sudden inrush of air could seriously damage an evacuated system. Keep plugs in upper ball valves for added security.

* If surge level increases more than an inch or so, take care not to overflow tank or standpipes. Consider removing gas bubble from loop. If vacuuming to lowest pressure would cause overflow, vacuum/backfill several times to a less extreme vacuum (e.g. 24"Hg or 20"Hg).

I. E. 15. Finish vacuum operation.

a. Recheck that manifold vacuum valve is shut.
b. Unplug vacuum pump.
c. Disconnect vacuum hose from manifold vacuum port; cap the port.
d. Disconnect other end of vacuum hose from vacuum pump. Remove cold trap from liquid nitrogen.
e. Return the liquid nitrogen to the storage dewar.

II. First day;.9 a.m.

A. Melt the freeze plugs soon after refreshing their argon.

1. Insulate the freeze standpipes with fiberglass batts..

2. Open upper manifold valves to surge tank and to adapter pipes. Open lower ball valves. Warning: upper ball valves must be shut and should also be plugged.

3. Crack open the upper manifold argon valve to supply 1 psi gauge argon pressure to the surge tank and freeze pipes.

4. Turn on the freeze pipe heaters, wired four in parallel, at 60 volts through variable transformer.

5. When all freeze standpipes are 250 C tighten U-bolt clamps to secure standpipes to enclosure frame. Do not overtighten as this will stress the pipes. The clamps are meant to stabilize the test sections against the weight and forces encountered during the stringer removal or replacement. The operator should use minimal force to avoid overstressing the test sections.

B. Prepare the puller pipe and assembly.

1. Rinse the shrouds, sleeves and fisher (puller rod) with hot water, distilled water, and, for the fisher, alcohol.

2. Dry the fisher in air. Dry the shrouds and sleeves in an oven at 170 C.

3. While the shrouds, sleeves and fishers are drying, preheat the puller pipes by connecting their tape heaters in series and driving them with about 75 volts (1.5 amps) from a dimmer circuit (typically dimmer D58).

II. B. 4. When the shrouds, sleeves and fishers are dry, assemble them and put them into the puller pipes, taking care not to touch the fisher, which will go into the lithium. Continue heating the puller pipes. Cap the lower ends to minimize air flow into the pipes.

C. When the freeze plugs are all melted, drain some lithium from the surge tank and freeze standpipes into the dump tank.

1. Make sure the freeze standpipes are all hotter than 250 C.

2. Make sure the "lower" dump valve is hotter than 200 C to avoid stressing the bellows against unmelted lithium.

3. Shut all valves on top and bottom gas manifolds.

4. Open gas valve between top and bottom manifolds. This valve is on pigtail of copper tubing at front of top manifold.

5. Unplug lower manifold vacuum port and crack the vacuum ball valve there to allow argon to purge through the tubing between the manifolds. Then close valve and plug.

6. On top manifold, carefully open surge tank gas valve, then gas valves to the adapter pipes.

7. Carefully and slowly open the lower ball valves. The lithium level in the surge tank should not change; it occasionally will oscillate slightly during this step.

8. Close the valve of the argon supply near the cylinder.

9. Open the upper manifold argon valve and the lower manifold gas valve to the dump tank. The pressure in the dump tank is now the same as that in the surge tank and freeze standpipes. Surge tank level should be stable.

10. Drain three inches of lithium out of surge tank and standpipes and into dump tank.(3" surge = about .3" dump). <u>Monitor levels of both surge and dump tanks during drain.</u>
    a. One operator should watch continuous level indicator.
    b. Second operator carefully opens "lower" dump valve. Not much force should be needed; open 1/4 turn.
    c. During drain, continuous level signal typically rises from 20 to 26 millivolts (lithium level drops from approximately 5 inches below the top of surge tank

to around 8 inches below the top of surge tank. The level in the standpipes correspondingly drops from about 3 inches to about 6 inches below lower ball valve.

II. C. 10. d. The short-out level probes should be watched to see if they respond at the correct level (although the lower probe should not respond since the level is not dropped far enough.)

e. When desired level (e.g., corresponding to 26 mv or 8 inches below top of surge tank) is shown on the continuous level indicator, the lithium dump valve is firmly but not forcefully closed. The valve handle is removed for security. (It will probably get quite hot if left on the stem during the drain, so the operator may choose to remove it during the drain. It should be kept in hand in case the valve must be shut suddenly.)

f. The dump tank gas valve and the manifold-to-manifold pigtail valve should be shut. All gas valves on the upper part of the loop can be left open as can the lower ball valves, to keep 1 psig argon pressure on the melted standpipe lithium. See however precautions in II.D.11.

D. Reset the safety circuits.

1. Open the continuous level recorder door, swing out the chart carriage, and turn off the power on the back of carriage.

2. Loosen the knurled nut on the recorder capstan. Rotate the fiberboard disks on the capstan to set the millivolt levels at which the "high" and "low" level microswitches are engaged. If the present reading is 26 millivolts, a "low level" setting of 29 millivolts and a "high level" setting of 23 millivolts are appropriate.

3. Retighten the knurled nut and rotate the capstan to check the new settings.

4. Turn the instrument power back on. The level indicator should move back to its position before the recorder had been shut off. The level will drop slightly (rise in millivoltage) as the lithium cools. The level will also drop (about 1/4 of inch) each time a stringer is removed, with a corresponding rise of about 1/2 millivolt in level indicator signal. If the level changes otherwise, check that the dump valve is fully shut.

II. D. 5. If the high-level short-out probe is not contacting lithium, remove the clipwire from the top of the probe and ground it onto part of the loop enclosure to close the safety relay associated with the probe.

6. The main heater temperature should be lower than the overtemperature at which the safety switch for the heater will open. If so, then all the safety switches (continuous level, short-out level, and overtemperature) are closed and the scram safety system can be reset.

7. Reset the latching safety relay at the bottom rear of the electromagnetic pump control cabinet. The relay should be pushed shut with a non-conductive instrument to avoid a shock or short. The relay will snap shut and hold itself closed if the safety switches in the scram system are all closed.

8. Turn the "automatic pump/heater interlock" switch to the override position. This allows the 208 volt heaters to be operated even though the pump is off. Only circuit "NO" should be connected to the main heater and only at 25% setting or less.

9. Flip the 208 volt heater power auto/manual mode switch to automatic. Replace the blocking bar. Remove the "key" from the manual enable spring switch.

10. Phone the University Police (262-2957 or 262-4524) and notify them that the loop is back to regular alarm operation. They should confirm that the alarm board no longer shows an alarm for the lithium loop. Any further alarms will be handled in the usual manner.

NOTE: 11. Use care if argon supply pressure is left open to standpipes and surge tank. Open supply to standpipes minimizes in-leakage of air and the accompanying nitriding. However open supply of argon is potentially hazardous. If a lithium leak occurs, the argon pressure (even 1 psig) would make the leak flow more readily, as the pressure is maintained by the argon supply system.

III. First day; 10:30 a.m. Stringers are in puller pipes,preheated.

A. Put two puller pipe assemblies on adapter pipes.

1. Remove plugs from top ball valves of proper test sections 1 & 2 or test sections 3 & 4. Blow any dust or grit off top of valves without opening them.

2. Screw the steel puller pipe into the brass ball valve, taking care not to strip the valve threads.

3. Reconnect the puller pipe heater tapes in series and restore power to them.

4. Connect a thermocouple to one of the pullers, The pipe wall should be 200 C to 250 C.

B. Operator should put on protective coveralls. Chrome leather greaves (for shins and feet),apron, jacket, and gloves are provided. Helmet should be worn during time when stringer is being removed or replaced from/to test section.

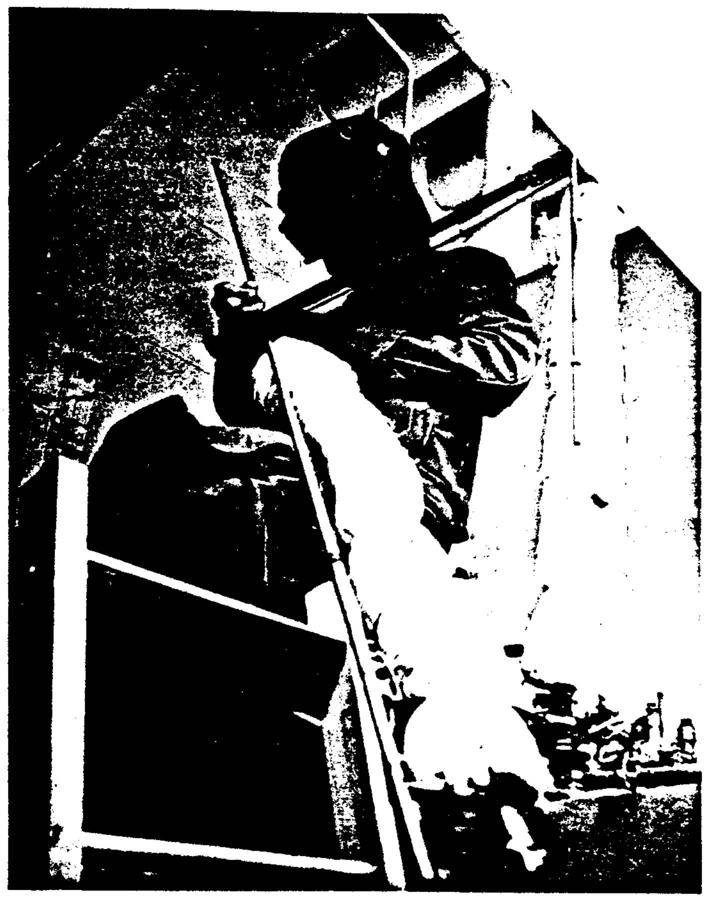
1. Argon pressure may be set at 2 psig for purge of puller pipe. Open the supply valve at the argon cylinder. Use the "biscuit" regulator to set pressure at 2 psig.

2. Check that all valves on top gas manifold are closed, and all ball valves are closed. Then open top manifold argon valve and gas valve to the desired adapter pipe.

3. Open the upper ball valve at the puller to be purged. Be sure before opening the valve that the fisher rod is cotter-pinned to keep it from falling through the adapter pipe when the top ball valve is opened. Open the top ball valve slowly, keeping an eye on the level indicator, which should not move. If it does move, a valve somewhere is open to lithium and must be shut.

4. Listen for argon hissing out of the top of the puller pipe as it purges the pipe.

5. Put the short sleeve on the middle-section fisher rod and screw the middle section rod into the lower section rod which is in the puller pipe. Set screw the two sections together with a small setscrew. Screw the setscrew in until it just clears the outside surface of the fisher.



OPERATOR READY TO REMOVE COUPON STRINGERS FROM LOOP --
INSULATED PIPE WILL BE PREHEATED TO RECEIVE STRINGER

III. B. 6. Shut top manifold argon valve.

7. Shut top ball valve.

8. Open surge tank gas valve. The level indicator should not change.

9. Open appropriate lower ball valve. Level indicator should not change. (Open valve slowly.)

10. Before opening top ball valve check that a cotter pin holds the fisher rod from dropping into the test section. At all times at least one cotter pin must be in the fisher. There should now be a cotter pin just above the puller pipe and also one at the top end of the middle section of the fisher rod.

11. Open the upper ball valve very slowly. The level indicator will probably jump as the pressure in the loop comes to atmospheric pressure. If such a jump occurs (up or down) shut the valve immediately and then try again. Only one jump should occur.

12. With both ball valves now wide open, remove the cotter pin holding the fisher,and lower it through the puller pipe. Use the sleeve to push the shroud down through the ball valves. When the shroud seats in the valves, pull the sleeve back out and cotter pin the middle fisher rod through the hole drilled halfway along its length. (Always hold or pin fisher.)

13. Remove the top cotter pin and slide the sleeve off the fisher. Replace the top cotter pin.

14. Remove the lower cotter pin and lower the fisher into the test section until the top cotter pin stops it. <u>Remember to always have at least one cotter pin in the fisher rod</u>.

15. Screw the top section of the fisher onto the middle section and set-screw the junction together. Cotter pin the top fisher halfway up its length.

16. Lower the fisher as far as possible before removing the middle cotter pin. The fisher will go down an inch or two further and then will stop as it hits the stringer in the bottom of the test section.

III. B. 17. Turn the fisher counterclockwise and feel the bump every revolution as the threads of the stringer and fisher pass over one another. Then twist the fisher 3-4 revolutions clockwise to attach it to the stringer.

18. Lift the fisher assembly with the attached stringer. Keep at least one cotter pin in the fisher at all times, and place it as far down as possible to minimize the shock should the assembly be dropped.

19. Remove the small set screw to free the top section of the fisher, and unscrew it from the lower sections.

20. When the middle fisher rod is halfway out of the puller pipe, the lower fisher will catch the shroud and begin to lift it out of the ball valves. The sleeve should not appear; if it does, push it down to prevent the shroud from coming out of the valves before the stringer has passed completely up through the valves. The shroud must protect the ball valves from the lithium now on the fisher and stringer.

21. When the lower fisher rod appears outside of the puller pipe, cotter pin it and close first the upper ball valve and then the lower ball valve. Immediately close the surge tank gas valve as well.

22. Service the other test section starting at III.B.2.

23. If the stringer should bind when being moved up through test section, do not pull, but reverse the direction of travel, rotate the fisher 90 degrees or so, and try again to pass through the tight place. If the fisher stops before going much lower than a few inches past the lower ball valve, there is probably a lithium or lithium nitride deposit blocking the standpipe. This may also be the case if the fisher passes downward with a little trouble but the larger-diameter stringer will not come through the standpipe when the fisher is raised. If this happens, the stringer must be replaced in the bottom of the test section and the fisher removed. The standpipe will have to be refilled, frozen and then cleaned out.

If the stringer binds when moving through the test section, remember to reverse it (a short, sharp rap in the reverse direction may be needed) and/or rotate it slightly rather than continuing to tug or push on the fisher.

IV. First day; stringer removed from loop and in puller pipes.

A. Turn off the puller heating tapes and unwrap their insulation to speed the cooling of the assemblies.

B. Refresh the argon in the loop. This should be done immediately, since air has diffused into standpipes and surge tank during stringer servicing. See procedure I. E.

C. Cool the puller pipes, preferably to below 150 C.

D. Rewrap the insulation onto the puller pipes, wind the heat tape wires around the pullers, and unscrew the pullers from the test sections. Wear gloves. If necessary use a wrench across the machined flats on puller bottom end to help loosen the puller from valve. Be sure the fisher rod is securely cotter-pinned before taking the puller off the test section. Plug the ball valve after removing the puller pipe.

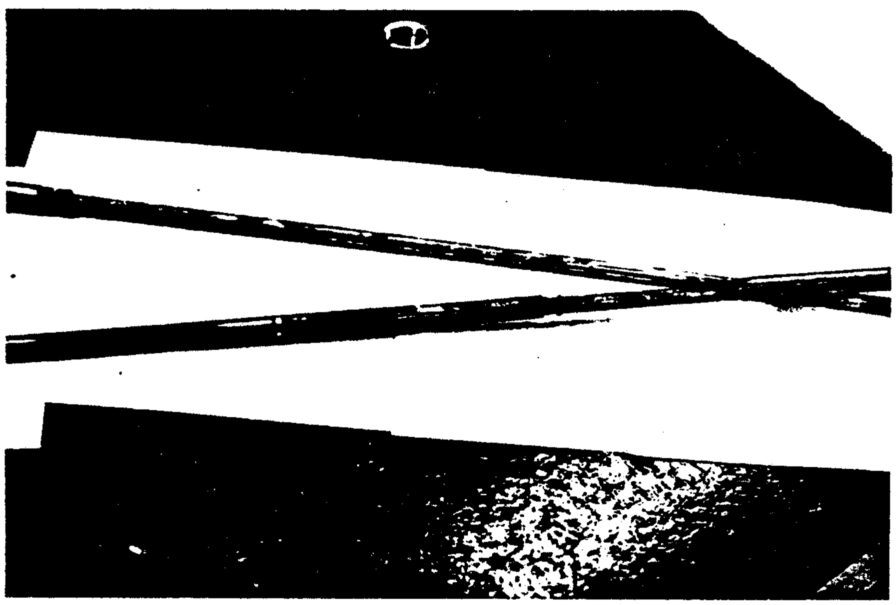
E. Take the puller pipes to the hood and remove the cotter pins from the fishers. Shake the assemblies out of the puller pipes.

F. Note the length of the fisher which is not at all wetted by lithium. Usually this is about 10 inches. The unwetted length minus 3 inches corresponds to how far the lithium is below the top of the standpipe (that is, below the lower ball valve). The unwetted length minus 1" is approximately the distance from the top of the surge tank to the level of the lithium in the tank.

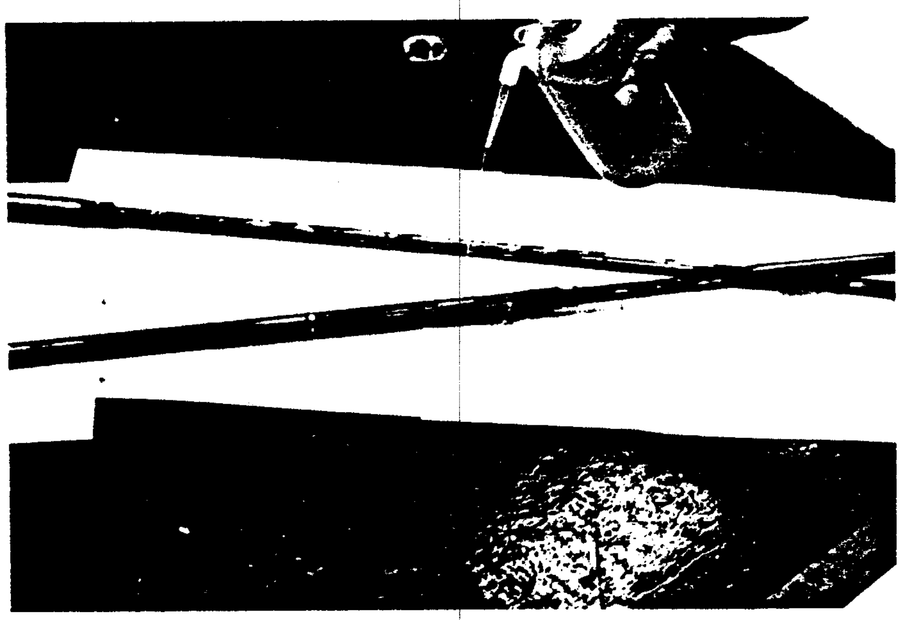
G. Note the appearance of the fisher rod; color and texture of lithium as function of distance down the rod. Also, is fisher rod completely wetted, spotty, etc.

H. When assembly has cooled so that a drop of water on the shroud does not immediately boil away, the assemblies can be immersed in water to begin cleaning them. (However, the assemblies are sometimes immersed in water at a temperature high enough to sizzle steam off when plunged into water; in this case the assembly should be pulled out of water for a moment and then reimmersed several times to reduce thermal shock somewhat. The possible effect of any such thermal shock on the corrosion rate has not been investigated in this laboratory.

It is convenient to clean the assemblies in a tank of water about 30" deep. Warm water is probably best, but hot tap water has been used for faster cleaning of the parts.



STRINGER, COATED WITH LITHIUM, AFTER REMOVAL FROM LOOP·



STRINGER, COATED WITH LITHIUM, WILL BE
IMMERSED IN LARGE TANK OF WATER
TO DISSOLVE LITHIUM

IV. I. Allow lithium to dissolve from fishers and shrouds. After fifteen minutes attempt to unscrew fisher from stringer. Grip top of fisher across flats with a wrench. Place a flat piece of metal in slot at bottom of stringer to hold it against turning while the fisher is twisted. Do not use so much force as to buckle the thin-walled tubing of the shroud, which may be stuck to the stringer until more lithium dissolves. The lower shroud tube is only .25 mm (.01") thick and is tack welded into the shroud at only a few points. Also, if bottom slot is burred or belled outward, stringer won't go into loop.

J. When fisher is free, place the lower nose end in boiling water if there is any lithium inside the end. Fifteen or twenty minutes is enough time to clean out the end. This is more likely to be necessary when the fisher has been used to replace a stringer to the loop. The weight of lithium in the stringer being removed from the loop usually pulls the lithium out of the fisher end. Since the stringer is left behind when replaced into the loop, the fisher usually comes out with lithium in the end.

K. Take precautions during cleaning of the lithium from the fisher and stringer.

1. Be careful with water around electrical circuitry.
2. Do not drop parts into tank of water. This damages edges, threads, thin walls, etc.
3. Lower small parts into water in a bucket on a wire to facilitate retrieval and keep from having to put hands into hydroxide solution.
4. Remove parts from water as soon as they are cleaned. This is especially important for coupons, as they rust quickly after exposure to lithium and this could affect the measured weight losses and/or corrosion rates.
5. Check stringer number to make sure it was in correct test section. It is a good idea to use one fisher rod and shroud for test sections 1 and 3 and the other set for sections 2 and 4.

6. When fishers, shrouds and sleeves are cleaned, use them to retrieve the other two stringers from the loop. Use procedures II.B.;III.; etc.
(As a precaution against contaminating the standpipes, use procedures VIII and IX to refill the surge tank and standpipes, after refreshing the argon there in step IV.B (according to procedure I.E.))

V. Disassembly, cleaning, weighing of coupons. (Days 1 and 2)

A. Take stringer apart.

1. Let water dissolve lithium out of slots in stringer.
2. Drain water off; blot with paper towel.
3. Break off wire-ties, using new wire or old wire-ties to pry up the wire out of the grooves in stringer.
4. Pry the two stringer halves apart with a small screwdriver. Be patient and don't use excessive force; the lithium may have to dissolve further before the stringer and coupons can be taken apart.
5. When stringer opens, check the coupons for proper order, set number, orientation in stringer.
6. As soon as possible, string the coupons in order in groups of eight on stainless wire.
7. Dissolve all the lithium off of the coupons and stringers, paying special attention to the fissures on the ends of the stringers.

B. Clean and dry the coupons and stringers.

1. Do not leave coupons or stringers in water any longer than necessary. They will rust.
2. Rinse with hot water, followed with distilled water.
3. A rinse with alcohol is optional if the coupons and stringers are to be oven dried immediately, but is necessary if they are to be air-dried.
4. Before weighing, the freshly cleaned coupons should be oven dried at 130 C for one hour, then cooled in air for one hour, then weighed immediately.

C. Weigh the coupons on the most precise balance available.

1. Do not touch coupons. Handle with paper towels, tweezers, and care while weighing.
2. Check the zero of balance at beginning, midway through, and at end of weighings.
3. Double check by calling off the weights if one person handles the balance and another person records the weights.
4. Reweigh two coupons at end of session to check reproducibility (usually better than 100 micrograms, often better than 50 micrograms.)
5. String coupons back onto the wires after they are weighed.
6. Coupons generally will be weighed early on second day of stringer service operation.

V. D. New or replacement coupons should be weighed with old.

1. Debur the coupons with a tubing cutter deburring tool.
2. Do not chamfer the inside diameter by excessive deburring. Inside surface should be free of machining marks.
3. Scribe identification numbers on specimen at two places, both at one end of coupon: identification format RRSPPX, where RR is run number, S is section number 1-4 (0 also used for "4"), and PP is the position of coupon, from 00 at the entrance to the test section, to 15 at the downstream end. The X notation is optional; it denotes a replacement coupon.
4. One of the identification numbers should be underlined to mark the coupon so it can be reassembled in the same orientation in the stringer each time.
5. An electric vibrator scriber is best for marking the coupons.
6. Clean new or replacement coupons inside and outside. Use a pipe cleaner to clean the inside. At this first cleaning, a detergent solution (alconox) and alcohol cleaning should be added to the regular hot water and distilled water rinses.
7. Oven dry the new/replacement coupons with the older coupons; weigh them at the same time.

If convenient, several "standard" coupons may be kept in a dessicator or other secure place between weighings and used as a quick check on the balance being used to weigh the coupons. Several "control" coupons, which are immersed in the cleaning tank and are rinsed and dried with the test coupons, may also be weighed at each session.

During the present work, however, neither control nor standard coupons were used.

VI. Reassemble stringers with weighed coupons (morning second day).

A. Do not handle the coupons or stringers except with paper towels or gloves. Use disposable plastic gloves. The wire ties will tear the fingertips so the gloves will have to be replaced frequently. Wipe the talcum powder off the gloves before their first use.

B. Put larger half of stringer on a clean surface with the threaded end (top) to the right. The coupons will then progress left to right from number 00 to number 15.

1. Slide correct coupon set off of holding wires and into trough in the stringer.
2. Coupons should be in proper order, 00 at the slotted left end of the stringer, 15 at the threaded right end.
3. The identification numbers should be at the left of each coupon. The underlined number should face the front.
4. Remember to place any replacement coupons in their proper places.
5. Double check coupons to be sure they are the correct set for the stringer, and that they are in the proper order, orientation, and fit smoothly in the stringer.

C. Coupon set should fit snugly in stringer.

1. If set is too long to fit in stringer, replace one non-critical coupon, such as the current replacement coupon if one is being introduced this time, with a shorter coupon from previous misfit (short) stocks. Debur, scribe, and clean this coupon as per procedure on previous page. Weigh the coupon if possible.

2. If set is too short (but not more than 0.02" or so); wedge a 0.02" stainless steel 316 wire between coupon 15 and the top of the stringer. Leave a half inch of wire extending out either side of stringer. Bend this wire down into the groove running up and down the stringer. The uppermost wire-tie will hold it in place; but it should be firmly wedged into the crack between the top coupon and the stringer.

VI. D. Close the stringer.

1. Place the smaller half of the stringer over the coupons and using gloved hands, lift the closed assembly with the left hand. Loosely wrap 2.5" long pieces of 0.02 inch type 316 stainless steel wire around the grooves in the stringer so that these "wire-ties" meet at the notched longitudinal slot of the stringer. (One of the slots is notched to receive the twisted ends of the wire-ties.)

2. Tighten the wire-ties partly with a pliers. Gently pry open the notched slot so that it is wide while the opposite slot closes. This makes more room for the wire twists. Twist the wire ties completely tight. When the ties are tight, a circumferencial force will not move them around in the groove. (A few trials can also be made to determine the breaking point of the wire. The tightening should be stopped short of this point.)

3. Cut the wire-twists so that 3/32" is left. Do not pull on the twists while cutting them or they may loosen. Push the twist over into the notch in the stringer so that the twist points toward the slotted bottom end of the stringer. Use a small screwdriver blade to force the twist down below the surface of the stringer so it will be less likely to catch. Sight down the stringer to see any protruding wires or nicks. Also run a gloved finger up and down the longitudinal slot to feel any wires sticking out. Make sure the stringer surface is smooth, especially at the bottom. Remove any burrs with a clean, dry fine file.

VII. Replace stringers into test sections. (Middle of second day)

A. If necessary, remelt freeze zones. Procedures I.E.; II.A.

B. Prepare puller pipe assembly. See procedures II.B. Screw the assembled stringer onto the dried fisher rod before adding the shroud and sleeve.

C. If necessary, drain some lithium from surge tank and standpipes. Procedure II. C.; II.D.

D. Replace the stringers into the test sections. Procedure III, except that step III.B.17 is to unscrew the fisher from the stringer by turning the fisher counterclockwise until the bump every revolution indicates that the parts are unscrewed. Vacuum and backfill the surge tank and standpipes; Proc. I.E.

E. Clean puller assembly: procedure IV. Replace other stringers.

VII. F. When replacing stringers into test sections, the operator should feel a positive stop as the stringer "hits bottom" of the test section. The slotted lower end of the stringer is designed to engage a stop in the test section. Engagement of the stop is not necessary so long as friction with the pipe walls keeps the stringer from rotating during the time when the fisher is being unscrewed. It is not crucial that the stringer go all the way to the stop but it should be within 2 1" of the stop. To date it had always been possible to lower the stringer right onto the stop.

VIII. Restore lithium level in surge tank and standpipes.

A. The lithium level should be raised in the surge tank and standpipes before the standpipes are frozen. The standpipes should be frozen whenever the lithium is being pumped in the loop and always when the loop is left unattended for long periods (i.e., overnight or longer).

B. Perform procedure I.C. to notify University Police of change in alarm status and to put heaters on manual mode.

C. Set the argon delivery pressure at the biscuit regulator to 3 psig. This will allow for pressure filling of the loop from the dump tank.

D. Ascertain that the "lower" dump valve is hotter than 200 C. Close all gas valves on loop. Close all ball valves on loop.

E. Open surge tank gas valve, (two) adapter pipe gas valves, and (four) lower ball valves carefully. Open pigtail valve to supply argon to lower manifold. Unplug and crack lower manifold vacuum valve to purge out the supply tubing. Close the vacuum valve and plug it. Open the dump tank gas valve to allow 3 psig pressure of argon to build in the dump tank.

F. With one operator watching the continuous level signal, the second operator opens the lower dump valve 1/4 to 1/2 turn and allows lithium to fill into loop. The desired level signal is 20 -22 mvolts, corresponding to having the surge tank filled to within 5 inches of the top. Monitor both surge and dump tank levels during filling.

G. As the lithium fills the standpipes and surge tank, it compresses the argon there until the pressure is high enough to prevent further filling. If this happens (usually two or three times during a refilling operation) close the dump valve to prevent any movement of lithium to or from the loop via the dump tank, and <u>crack</u> open the upper gas manifold's vacuum valve to allow the argon there to bleed partly but not completely out. (0<psig<1.) Then close the top manifold vacuum valve and reopen the dump valve to admit more lithium to the loop. (See also notes following part IX.F.)

VIII. H. If the short-out probes on the surge tank are operating, check if they are activated at the expected level(s).

I. When the surge tank is filled to desired level, close the dump valve firmly but not forcefully. Remove the dump valve handle. Shut the dump tank gas valve. Shut the pigtail valve between the argon supply and the lower gas manifold. Shut ball valves, then gas valves on loop.

J. Reduce the argon supply pressure at the biscuit regulator to 1 psig.

K. Remove any puller pipes from the test sections, and plug the upper ball valves with standard brass pipe plugs. Unclamp the standpipes. Turn off and unplug the heat to the standpipes. Roll the insulation away from them. Keep an argon pressure on the standpipes while the lithium freezes. See procedure II.A.1-2. When lithium is frozen, shut the ball valves and the surge tank gas valve. Usually, adapter gas valves and the top manifold argon valve are left cracked open to keep a positive pressure on the adapters at all times. A supply pressure should not be connected to the surge tank since it would be dangerous in the event of a lithium leak. (See part II.D.11)

IX. Vacuum and backfill the dump tank.

A. Close the pigtail gas valve between argon supply and the lower gas manifold. Close all valves on lower gas manifold.

B. Attach a liquid nitrogen cold-trapped roughing vacuum pump to the lower gas manifold vacuum port. Turn on the pump.

C. Open the lower gas manifold vacuum valve. Pressure gauge should immediately go to about -30"Hg vacuum.

D. Bleed some argon through the pigtail and hear the argon gurgle through the vacuum pump (this purges out the argon tubing). Close pigtail valve. Pump should quiet down quickly.

IX. E. Crack open the dump tank gas valve slowly and allow to evacuate until lower manifold gauge reads about 15" Hg, then open the dump gas valve fully. In about a minute the tank should be evacuated and the vacuum pump will quiet down. Allow the pump to vacuum the tank well (~2 minutes), then close the vacuum valve and crack open the pigtail argon valve to slowly backfill the dump tank with argon until the pressure, as measured on the manifold gauge next to the dump tank, is about one psi gauge. Close the dump tank gas valve and the argon pigtail valve.

F. Turn off vacuum pump. Disconnect the vacuum line from the lower manifold vacuum port and plug the port. Return the liquid nitrogen to the storage dewar.

NOTE: Close the top manifold argon valve when servicing the dump tank to avoid placing partial vacuum on upper manifold. This is a safety precaution in case one of the top manifold valves had been left open to the loop.

Occasionally check valve stems to be sure they are not loose. Tighten stem nuts on any valves requiring this service. (This, generally, applies only to gas valves.)

NOTE: To hasten the filling of the surge tank (from the dump tank) apply a slight vacuum to the top of the loop (including surge tank, and also any standpipes that are thawed), then close the vacuum valve and open the dump valve to allow lithium into the loop. One should stay near the dump valve whenever it is open, and especially if the vacuum fill is used, since it can be faster than a pressure fill with only 1 or 2 psig in the dump tank. It is advisable to keep the valve handle on the dump valve while the valve is opened.

Add argon to the top of the loop to relieve any vacuum remaining there after this type of filling.

X. Restarting the pumped-flow operation of loop. (Evening 2nd day.)

A. Reset safety circuits with procedure II.D. Reconnect the short-out level probes if they have been disconnected or shunted during the stringer servicing operations.

B. Set radiator heaters to higher range of settings given in Table L.1. Monitor radiator temperatures and temperatures of radiator U-bends to prevent overheating.

C. Reducing the ventilation through the laboratory may help warm the radiator. However, once the radiator is quite hot, spots which have not yet thawed (usually in the U-bends and lower part of the radiator) can be further warmed by turning on the laboratory hood fan. This causes a slight suction of air down through the hotter top of the radiator to the cooler lower regions.

D. When all blockages have been thawed, thermal convection may cause a lithium flow to start. This will be signaled in the radiator by rapidly changing temperatures and should be watched for with the digital thermocouple readout or by keeping an eye on the radiator temperature controller readout. In some cases the loop may be ready to restart (that is, all blockages gone) without the temperatures showing any dramatic changes, but frequently such signs will accompany the complete thaw of lithium in the radiator.

E. Turn on the pump for 2-3 seconds and see if the digital thermocouple readout shows a change indicating lithium flow. If no change is seen, turn off the pump and wait for further thawing.

F. Once the pump does move the lithium, turn the pump to 2% and do not immediately leave it running continuously. Rather, turn the pump on about ten seconds of every minute until the radiator temperatures have equalized. The upper radiator is usually at 400 C and will drop to about 300C as flow continues. This is a rather large drop and should not take place rapidly or the radiator may be stressed unnecessarily.

G. When pumped flow is possible and while the radiator is cooling from the extreme standby temperatures in the upper parts, the radiator heater should be rewired as in procedure I.B., except that the "normal" fanning strip should now replace the "standby" strip.

X. H. The pump should now be turned on for good at 4% power (to be increased shortly to 10%) and the main heater clamshell circuits and radiator heaters should be set to the conditions given in Table L.1 for "normal" operation. The dimmers listed in the table should be wired and/or set as noted for normal operation.

I. During the reheating of the pumped loop to the test conditions, the main heater circuits LM and NO/PQ may be run at 90% power settings. When the lithium temperature is within 30 degrees C of the maximum temperature, these heaters should be returned to their "normal" settings to prevent overshooting the setpoint temperature.

J. When the temperature of the loop (maximum temperature) has come within 30 degrees C of the desired maximum temperature, the pump setting should be increased to 10% power.

K. Control systems should be adjusted: Plug in the pump slowdown servomoter. Flip the pump/heater interlock switch from "override" to "automatic safety." Place the flowmeter "low-flow" mercury switch back into its clip on the drive wheel inside the recorder, behind chart. Change radiator control thermocouple from the finned pipe to an insulated pipe just downstream of the radiator, so that the lithium temperature (important for flow operation) is controlled rather than the radiator housing temperature (important for non-flow operation). Open the radiator damper slightly if needed to keep the radiator temperature below the desired value. Switch the damper mode switch to automatic operation if it is not already so set. Turn heater variable transformer NOPQ to 70-75% or so, as the maximum temperature is reached. (See procedure X.I.)

M. During reheating to operating temperature, the lithium will expand slightly, increasing the surge tank lithium level by 1" or so. If necessary to maintain a safe level in the surge tank, drain a small amount of lithium into the dump tank by simply cracking open the lower drain valve. After the loop is at temperature, reduce the heating to the drain valve or it may slowly leak lithium into the dump tank. The heater on the pipe above the drain valve may also have to be turned down slightly.
NOTE HOWEVER: If the lithium should ever have to be drained suddenly, having the valve much below the melting point of lithium would be a safety hazard.

N. Monitor the loop temperatures until steady state is attained to assure that the temperature does not overshoot or fail to reach the desired test temperature. Measure the flowmeter outputs with a manual potentiometer within a day after restarting the loop and again several times during the test run. Log the temperatures and heater control settings at least one time during the test run. Temperatures should be measured using a digital thermocouple readout. The flowmeter leads can be quickly removed from the recorder terminals and leads from the potentiometer clipped onto the flow meter leads. The potentiometer should be standardized several times during the measurement of the flow rates. The flow rates should be taken as the average of three readings for each meter. To avoid biased measurements, the potentiometer should be balanced by observing only the galvanometer and not the millivoltage dial. Between the triplicate readings, the potentiometer should be deliberately unbalanced so the three estimates are independent.

APPENDIX M. LITHIUM SAMPLING

EQUIPMENT AND PROCEDURE

Lithium sampling [5-90ff; 7-45,56]

Lithium samples are taken by connecting an evacuated bypass tube across the valved ports on each side of the electromagnetic pump. After the tubing has been evacuated and preheated, the preheated bypass valves are opened to allow the pump to circulate lithium through the bypass tubing. Several hours of such bypass flow should minimize the effect of impurities which might have been present initially in the tube or in the sampler ports or valves. In practice the bypass sampler will be slightly cooler than the lithium passing through it and this may cause some precipitation of impurities in the sampler. After several hours of bypass flow the valves are closed, the tubing cooled, and the sampler removed from the loop.

Procedure

I. Preparation of sampler.

A. Cut stainless tubing as indicated in Table M.1, depending on whether a 1/4" or 1/2" sampler is desired. Cut the smaller diameter tubing with a tubing cutter having a cutting wheel suited for stainless steel. Cut the larger tube with a hacksaw or in a lathe. If a vise is used to hold the tube, it should have copper or brass jaws and should be clamped only lightly on the tube to prevent distorting the tube.

B. Debur the tube ends. Wash tubes and fittings in hot detergent solution. Clean the inside of smaller tubing with pipe cleaners sold for tobacco pipes. Clean the inside of the larger tubing with a test tube brush. Rinse the parts in hot water followed by distilled water and methanol. Dry the parts.

TABLE M.1. MATERIALS FOR LITHIUM SAMPLER

ITEM	FOR 1/2" SAMPLER	FOR 1/4" SAMPLER
stainless steel tubing SS304, 1/4" OD x .020"		
part A	5-1/4"	6-1/2"
part B	5"	18-3/4"
part C	11-1/2"	11-1/2"
part D	1-1/2"	---
stainless steel tubing SS304, 1/2" OD x .020"	11-3/4"	---
lengths not critical but finished assembly must fit across the valve ports (∿20")		
Swagelok parts: 1/4"		
stainless tee(+3ferrule sets)	1	1
stainless cap(+1ferrule set ea)	2	2
brass cap (+1 ferrule set)	1	1
brass valve	1	1
Swagelok part : 1/4"-1/2"		
stainless reducing union (+ 1/2 and 1/4" ferrule set for each)	2	---

Stainless steel plugs (2) must be kept in the valve ports when the sampler is not attached. These are 1/4" size.

I. C. Refer to Figure M.1 for assembly of the sampler.

1. Form elbows A and B to each have a 3" arm which will fit into the valve ports on the loop. Use a 1/4" tubing bender and make 90 degree bends.

2. Assemble the fittings and tubing to the right of point X. Tighten the Swageloks loosely to hold the assembly together. If desired, seat the tubing into each fitting and then withdraw it slightly (1/8" for 1/4" tube; 1/4" for the 1/2" tube) before tightening. The short length of tubing in the fitting should not affect the swagelock seal as long as enough is left for the ferrules to bite securely into. The shorter length will make disassembly easier after lithium has wet the fittings.

3. Add part B to the assembly. If necessary, reduce the length of B by cutting off just enough to reduce the overall sampler length so that it will just fit across the sampler ports (about 20 inches). Remember to debur any new cuts.

4. Tighten Swagelok fittings according to manufacturer's recommendations. If necessary carefully lubricate the fitting threads (not ferrules or seats) with a bit of inert, high temperature grease to prevent galling and make tightening easier.

5. Using a brass ferrule, attach a brass Swagelok valve to the end of part C. Bend tube C 120 degrees as shown. Using tube caps, seat stainless steel ferrules onto the open ends of elbows A and B.

6. Take the sampler apart and rinse it with alcohol. Dry it in an oven at 140C for one hour (brass parts for only 15 minutes). Cool the parts and reassemble. Tighten the Swageloks securely.

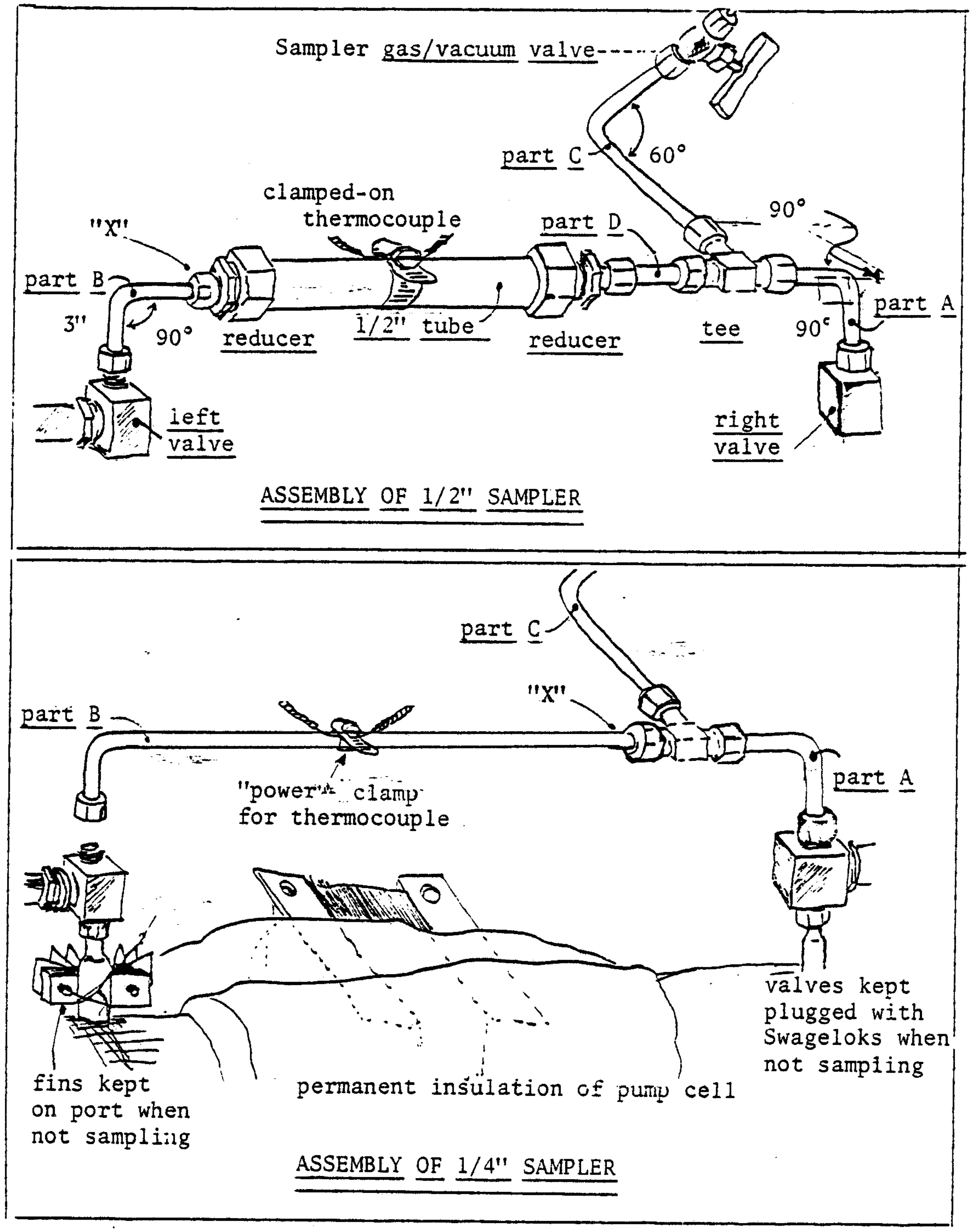


FIGURE M.1: LITHIUM SAMPLERS

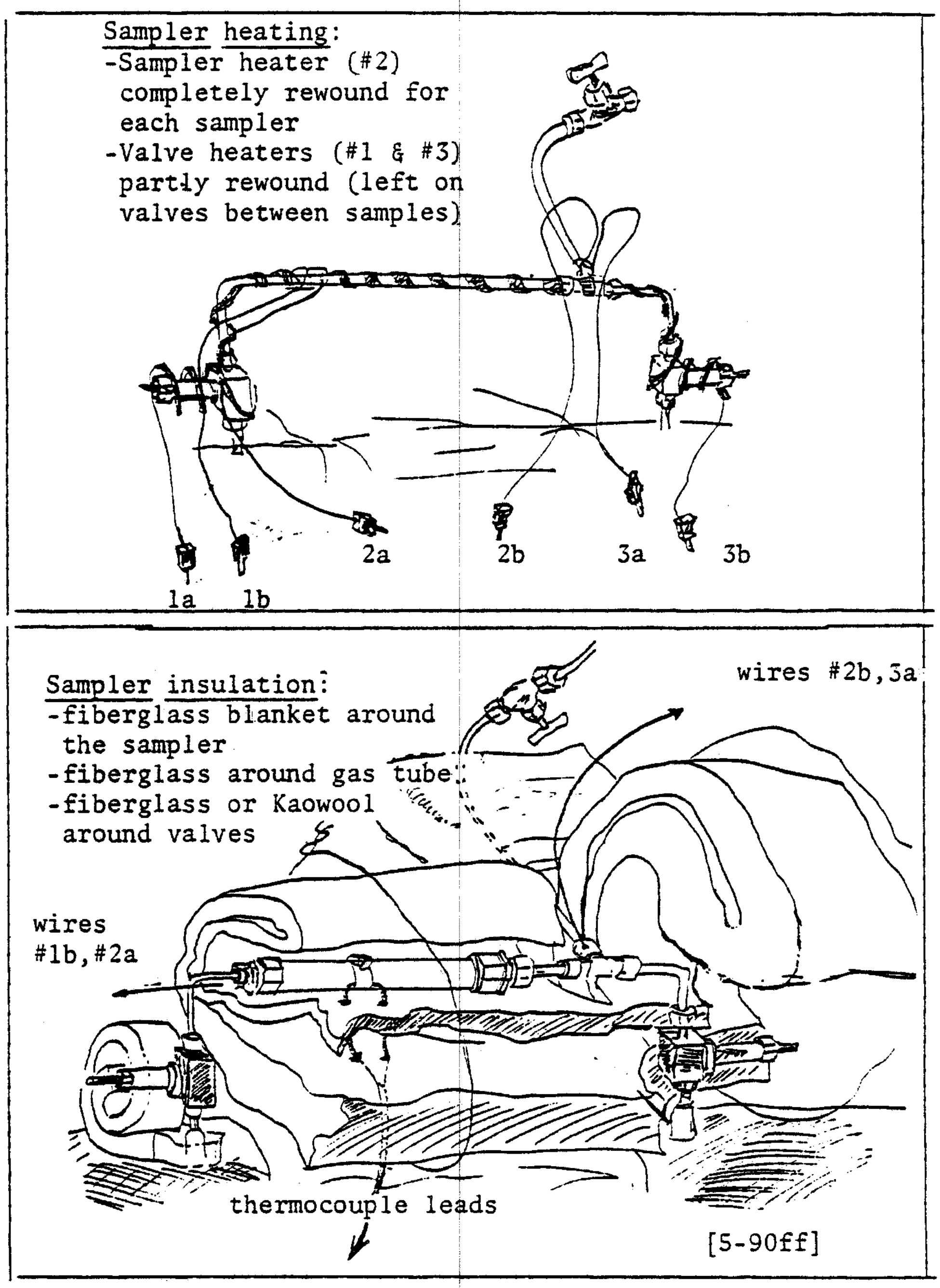
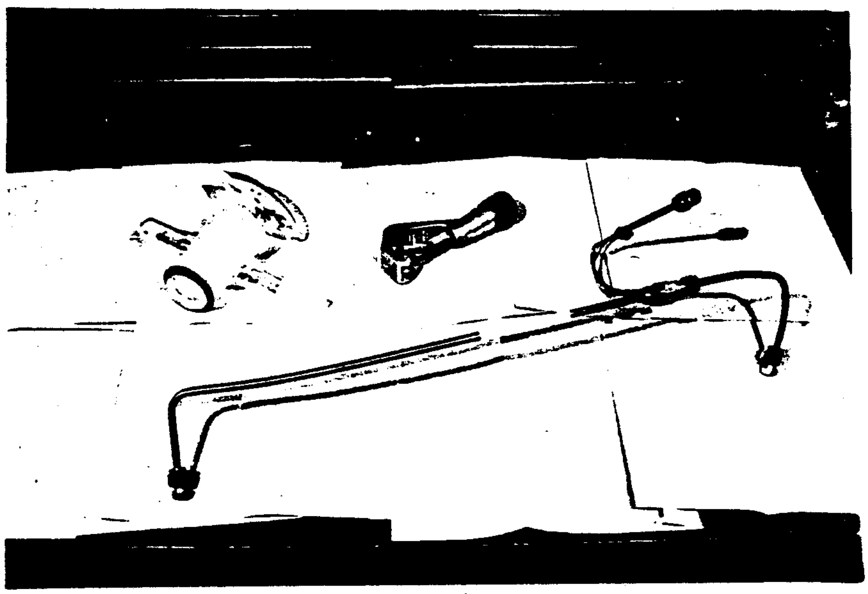


FIGURE M.2: LITHIUM SAMPLER--HEATERS & INSULATION



LITHIUM SAMPLER BYPASS TUBE ASSEMBLY

II. Preheating and vacuuming of sampler.

A. Fasten a bead-insulated chromel-alumel (type K) thermocouple to the sampler with a stainless steel hose clamp.

B. Remove fins and plugs cautiously from bypass valves. The valves should be shut but be careful anyway when unplugging the valves.

C. Put the sampler into the valves. If it doesn't fit remove it and bend the elbows A and B to make it fit. Do not try to bend the sampler while it is in the valves or you may strain the valves. Tighten the Swageloks according to the recommended procedure. The fitting threads (not ferrules or seats) may be greased lightly if needed (see above).
Be careful not to strain or loosen the valves themselves while tightening the tubing into them. A dangerous leak might then occur. Hold the valve body block with an adjustable wrench and try not to twist or bend the valve. It is best to tighten the (right-side) fitting by holding the nut in a small open-end wrench positioned at a small angle to the wrench holding the valve block. With fingers braced on the larger wrench handle, push the smaller wrench with the palm of the hand, closing the angle between the wrenches and tightening the nut slightly. The larger wrench and the valve itself should not move at all. The nut may be tightened in small steps. (The position of the fingers and palm is reversed for tightening the left-side fitting.) This procedure is also necessary when loosening the fittings after the sample has been taken, with appropriate repositioning of the wrenches.

D. Disconnect the brass Swagelok valve to the shipping tank lithium sample port from the copper tubing above the electromagnetic pump inside the loop enclosure. Connect the sampler brass valve into the tubing so that argon or vacuum can be delivered to the sampler. Tighten this Swagelok connection.

E. Vacuum and backfill (with argon) the sampler several times through the lower gas manifold, using a liquid-nitrogen cold-trapped roughing pump. Tighten fittings as needed to make the sampler leak-tight.* Then vacuum for one hour or more until ready to sample. During preheating the sampler may be backfilled with argon once or twice if desired but should be under vacuum for a full 10 minutes before sampling.
BE SURE to CLOSE gas valve on sampler before sampling!
*Vacuum test: vacuum sampler and manifold together. Close vacuum valve. Pressure should change less than 2" Hg /10 minutes in the combined (and connected) sampler, manifold and gauge.

II. F. After vacuum has been tested, wrap the sampler with three heating tapes as shown in Figure M.2. The tapes are 1/2" x 24" long, 144 watts at 120 volts. They are heavily insulated with "Samox" braid for operation at up to 800C on bare metal. The end heaters of the sampler operate in parallel on one circuit; the central heater runs alone on a second circuit.

G. Wrap sampler with fiberglass blanket insulation as shown in Figure M.2. Bring out heater and thermocouple leads as shown. Secure the insulation in place with stainless wire. Wire with a . 0.02 inch diameter works well for securing the insulation. Wrap or wad glass or Kaowool insulation around the valve stems and blocks.

H. Connect thermocouple from one of the valve stems to a recorder. Turn on the heaters at a low setting and preheat sampler while continuing the vacuum. A moderately slow heating rate should bring the sampler to 250C in 1/2 to 1 hour. Remember that the inside of the valves will heat slowly, and the lithium inside must melt before the valve can safely be opened. Let the heat "soak" into the valve for at least half an hour to insure the total melting of the lithium in the bellows.

III. Taking the lithium sample.

A. Two operators should be present whenever valves are opened or closed. The loop should not be left unattended during bypass sampling.

B. Close the brass valve, sealing the sampler under vacuum. Monitor the sampler temperature with the digital thermocouple readout. Check that both valves are hotter than 200C.

C. Carefully open one of the bypass valves. The sampler temperature should rise about 50 degrees C, typically -- thereby showing that lithium has flowed into the sampler.

D. Carefully open the second valve. The sampler temperature should again rise, this time to within 30 degrees C of the pump cell temperature, showing that the lithium is flowing through the bypass sampler. Both valves should be opened about 1 turn; note how far each has been opened. This will help you judge when the sample bypass valves are fully tight when you close them after the sample is taken.

IV. Finishing the lithium sampling.

A. Close the two bypass valves firmly. Their closed positions should be in agreement with the positions noted at the start of the bypass operation. Close the valves firmly but do not overtighten.

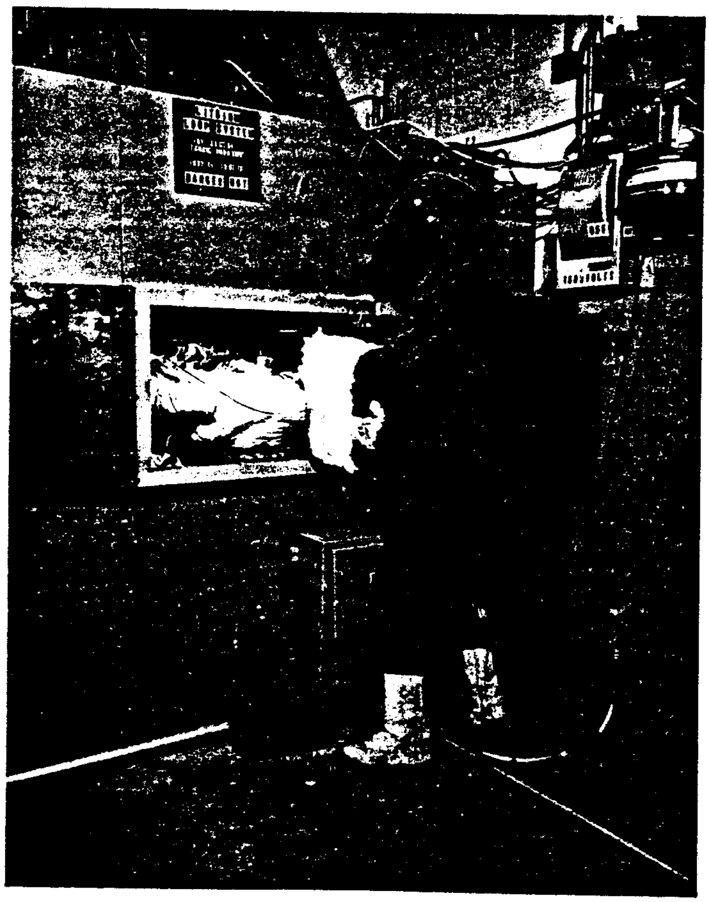
B. Turn off the sampler heating tapes. Unplug them but do not unplug the heating tape to the pump cell. The plugs will be easily mistaken for one another.

C. Unwrap the sampler insulation. The insulation will be scorched and the stainless parts a bronze color. Check for signs of any lithium leaks--metallic or salty crusts around fittings or on insulation. Leaks are not expected. When it is cool, sampler gas valve may be disconnected from supply.

D. Let the sampler and valves cool.* Then, loosen the sampler from the valves with the same care and technique outlined in part II.C. Do not loosen the valves themselves from their connections to the loop, since these usually run hot enough to allow the lithium inside to be molten; leak would occur.
*Sampler and elbows must freeze for safety; valves might not.

E. It may be difficult to remove the sampler from the valves due to the solid core of lithium in the tube where the sampler joins the valves. Take care again not to strain the valves. A considerable amount of force may be required to release the sampler. If possible use tools and ingenuity to apply the force without straining the valves. It may be necessary to grip the sampler elbows A and B at the bends with a visegrips and try to pull or twist the sampler up out of the valve. A sharp rap upward on the sampler at these points may help free the fittings. If one end can be freed, the sampler can be swung in and out around the other valve to help work the fitting free. In every case, keep an adjustable wrench on the body of either valve which is being stressed, to help reduce the ill effects of such strain.

F. Plug the valve ports with the plug fittings set aside when the sampler was originally put in place. Also cap the ends of the sampler. Plug or cap immediately after the fitting is apart. Tighten the plug or cap with a small amount of force. It is desired to keep air out of the fitting, but the fitting need not be especially leak-tight (although a secure plug in the valve is an added safety margin in case the valve is accidently opened.)



OPERATOR REMOVING LITHIUM SAMPLER FROM PUMP BYPASS PORTS

IV. G. Crimp the sampler tubes on the elbows if desired; this may help keep the sampler free of contamination (by air which might diffuse along the inside wall of the sampler. Lithium shrinks when cooling and could presumably leave a void in places.) Crimping would more easily be accomplished when the lithium was still molten in the sampler, but this would be less safe. Samples taken at this lab have not been crimped.

H. Disconnect the copper gas supply tubing from the sampler's gas valve if it was not disconnected (more conveniently) before removing the sampler from the ports (e.g. step IV.C). Leave the brass valve on the sampler for the time being, or replace it with a tube cap. Reconnect the copper gas supply tubing to the gas valve leading to the shipping tank sampler port. Vacuum and backfill the tubing to remove air which got in during the changes.

I. Disconnect the thermocouple, unwrap the central heater tape, and label the sampler with the date. Before sectioning the sampler for analyses, sand off the oxide and wipe the sampler with alcohol. Analyses should be made as soon as possible after sampling the lithium. [7-57ff; 5-111].

APPENDIX N. ANALYTICAL METHODS AND RESULTS

PROCEDURES FOR LITHIUM SAMPLES

PROCEDURES FOR STAINLESS STEEL COUPONS

includes:

Lithium analysis results
Optical microscopy
Scanning electron microscopy
Electron microprobe composition profiles

Nitrogen in lithium: Kjeldahl method

Nitrogen in lithium exists as the nitride, Li_3N, which is formed even at room temperature. The nitride hydrolizes readily to form ammonia and lithium hydroxide. The lithium sample must be kept from reacting with atmospheric nitrogen. Two methods of sectioning the sample are:

1.) Using a clean, dry tubing cutter, cut the lithium sample tube in an argon atmosphere glove box. Place a 1-1/2" piece of the sample into a large, clean vacuum stopcock with carefully greased joints. Transfer to a special Kjeldahl reactor from which nitrogen is excluded, and follow procedure similar to that given by Laing (1976), by Ward (1963), or by Schlager (1975). The use of a glove box is the standard method. It requires a very-high purity glove box atmosphere. The sample need not be analyzed immediately after cutting it, but it should be analyzed within a day.

2.) Deep-freeze the end of the lithium sample tube in liquid nitrogen (for about three minutes). Cut off the end, using a clean, dry tubing cutter. If the end was previously cut, cut off and discard enough length so that any nitrided or oxidized lithium is removed.

Keep the tube well chilled by dipping it in the liquid nitrogen. Make a second (and third, if needed) cut just through the stainless tube so that a 1-1/2" piece of the sample can be broken off. Hold the chilled tube with pliers or visegrips and snap the piece off. The ends should be a very clean silvery metal.

The sample must immediately be submerged into cold distilled water in the Kjeldahl vessel, which is then closed. A Kjeldahl set-up similar to that of Schlager (1975) is used. Basically, it consists of a 1 liter, 2- or 3-necked glass flask, with greased rubber stoppers used to plug the openings. The ultra-cold lithium sample is dropped through one of the openings before it is closed. An inverted glass U-tube connects one of the other openings to a simple water-cooled condenser. The lower end of the condenser should be submerged in a solution of 2 drops of concentrated sulfuric acid in 25 ml of distilled water. The distillate receiver is a 100 ml Erlenmeyer flask.

There must be enough cold distilled water in the 1 liter flask to completely cover the lithium sample and so prevent air from reaching it.

The reactor flask can be heated with a hot plate or electric mantle, but no flames should be used, since hydrogen is generated during the dissolution of the lithium The operation should be carried out in a hood, if possible.

Heating the reactor flask will cause steam and ammonia to distill off from the lithium hydroxide solution. The lithium should be allowed to dissolve completely before heating commences. A thin blanket of insulation around the flask will speed the distillation.

Distill about 50 ml of water into the Erlenmeyer receiver. Pour the distillate solution into a 100 ml volumetric flask, Rinse the Erlenmeyer flask two or three times with a little distilled water, adding the rinses to the volumetric flask. Add one drop of (non-nitrogenous) indicator dye and dilute to the 100 ml mark.

Pour the concentrated LiOH solution from the reactor flask into a 1 liter volumetric flask. Be careful, especially if the solution is hot, since it is caustic. Rinse the reactor several times with distilled water, using a rubber-ended spatula to dislodge LiOH crystals from the walls. Pour the rinses into the 1 liter volumetric flask, then cool it to room temperature and dilute to the mark.

Titrate several 10ml aliquots of the LiOH solution to determine the amount of lithium in the sample. Use 1N HCl for the titrant. The amount of lithium can be roughly estimated by measuring the length and/or mass of the empty section of sample tube, from which the lithium was dissolved.

Measure the amount of $(NH_4)_2SO_4$ in the distillate electrochemically (Orion, 1975,1978) or by standard NH_4 methods. The University of Wisconsin State Soils Laboratory (802 S. Park Street) has analyzed several samples for us. Measure the ammonium content as soon as possible; keep the samples chilled in the meantime to prevent the growth of microorganisms in the solutions.

Analysis for Oxygen in Lithium

Neutron activation analysis is the best method of measuring the oxygen content of lithium (see literature review for brief discussion; see also Yonco et al. (1979).

One sample of the lithium from the 450-255C test was analyzed for oxygen content. The analysis was performed at the Oak Ridge National Laboratory. The oxygen content of the lithium was 275ppm.

Analysis for Metallic Impurities in Lithium:

Ion-Coupled Plasma Spectrophotometry

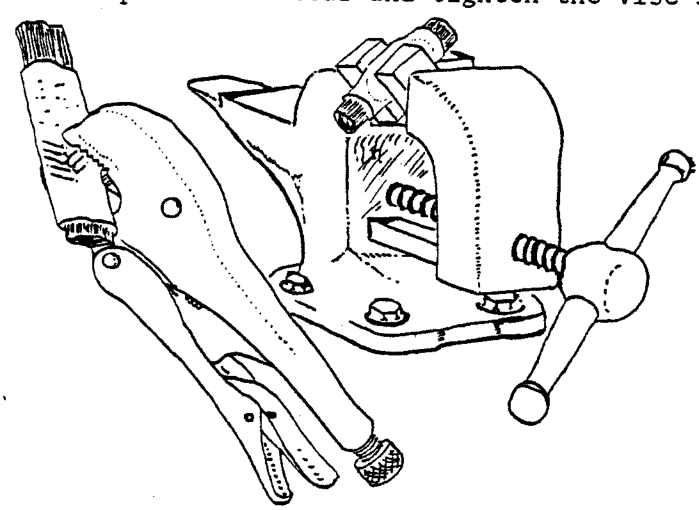
This procedure will provide a replicated sample for ICP analysis.

Clean, dry and weigh two, 2 ounce plastic bottles with plastic screw-on caps. Each will receive 1-1.5 grams of lithium.

Clean the lithium sampler tube by wire-brushing and sanding, then wipe it with alcohol and let it dry.

At room temperature, cut a 2-1/2 inch piece from the (1/2" diameter) sampler tube of lithium. If the sampler had previously been cut, remove the oxidized end before cutting this sample.

Use a clean visegrip pliers or a clean vise to apply pressure and extrude the lithium from the tube. If a vise is used, hold the tube between two 2" pieces of metal and tighten the vise slowly to



squeeze out lithium from both ends. Do not allow the extruded lithium to touch anything; this might introduce extraneous contamination. When the tubing is flattened, put the plastic bottle over one of the two extruded sticks of lithium, and work the lithium back and forth with the bottle to break it off and into the bottle.

If a visegrip pliers is used to extrude the lithium, start flattening the tube at the center and work toward the ends. Gradually close the visegrip setting so that successive applications flatten the sample tube. Finish the extrusion by applying the flat part of the visegrip jaws in a herringbone pattern (see illustration on previous page) to drive most of the lithium out each end.

The lithium should be clean and silvery as it is extruded, but it will nitride to a blue-black immediately.

Weigh the bottle with the lithium to determine the lithium weight. The amount of lithium will also be checked by titration (during the dissolution and neutralization step which comes next) but the solution may mist and some of the titrant be lost, so the weighing at this point is probably the better measure of the amount of lithium in the sample.

The lithium can be titrated with concentrated HCl, as this will minimize the amount of impurities added in any distilled water otherwise used for dilution of the acid. Titration should be done in a hood, if possible. The exact concentration of the acid should be determined by titration against a standard base. For this, a diluted solution of the acid may be used.

Titrate the lithium in the plastic bottle. During the titration swirl the bottle in a pail of cold water, using care not to spill the solution into the cooling water, or vice versa. Add no more than 1 ml of concentrated HCl at a time, quickly cap the bottle (loosely) to minimize the escape of aerosol mists, and swirl in the cold water until the solution cools. Each addition of HCl will cause the solution to boil and give off hydrogen and steam. The bottle may melt if not cooled in the water, and would be too hot to handle. Even with cooling, it will be uncomfortable to hold the bottle, and rubber gloves are recommended both for this reason and also to protect the hands against acid or hydroxide burns. Safety goggles should be worn to protect the eyes.

The titration (which dissolves and neutralizes the lithium) requires about 15 ml of concentrated HCl per gram of lithium. At first a white slurry of LiOH and LiCl will form as the lithium dissolves and is neutralized. Some of the water in the 37% HCl will boil away. Very little free water will be present.

When all of the lithium has dissolved, the evolution of heat may decrease slightly, and the slurry will begin to clear as water from the HCl no longer is consumed by the dissolution of lithium. Additional water will be formed as the acid and hydroxide neutralize each other. Two drops of methyl red indicator should be added to the bottle when the lithium has dissolved.

As titration continues, the solution will clear completely and turn pink at the neutral point. The volume should be 20 ml or less. One or two more drops of the concentrated HCl should be added to bring the pH to 2 or less, in order to prevent insoluble hydroxides (such as iron hydroxide) from being present. The solution is now poured into a 25ml volumetric flask, diluted to volume with distilled water, and poured back into the plastic bottle. The bottle is tightly capped and labeled. The ion-coupled plasma analysis should be carried out within two weeks.

The limits of detection for ion-coupled plasma analyses of Fe, Cr, Ni and Mo (in the final LiCl solution) are 0.011, 0.017, 0.037, and 0.021 ppm by weight. If one gram of lithium is used to make the sample, the limits of detection based on the lithium weight are 0.27, 0.42, 0.92, and 0.51 ppm respectively.

Blank samples of distilled water with two drops of methyl red indicator contained 0.05ppm of iron and undetectable amounts of the other metals. This corresponds to a blank of 1.25 ppm of iron in a one gram sample of lithium, dissolved in 25 ml of distilled water. Since most of the dissolution is by the acid solution, a blank determination with distilled water is only an estimate of what the true blank might be. The maximum iron content in concentrated HCl is given as 0.00001% (0.1ppm) by the manufacturer. The addition of 20 ml of this acid (if it contains the maximum amount of iron) would introduce 2 ppm of iron into the final sample (based on a one gram original lithium sample.) A total blank of 1.25 ppm seems reasonable. The purest water and acid available should be used.

Analysis for Metallic Impurities in Lithium:

D C Arc Spectrography

Contamination of the lithium sample by nitrogen is no problem here; the lithium may be cut in air at room temperature.

Clean the outside of the sample tube with alcohol. Using a clean, dry tubing cutter, cut the tube to obtain a fresh, clean lithium surface. A nitride layer will probably form, but this should not affect analysis for metallic impurities.

Gouge about 0.1 gram of lithium from the inner part of the lithium, using a clean, dry stainless steel spatula. The spatula should be small enough not to scrape lithium from the walls of the tube. Place the lithium lump in a small, clean plastic beaker. Dissolve it about 1 ml of distilled water. Titrate the LiOH solution with 2N HCl to determine the amount of lithium present. Pour the resulting solution into a 10 ml volumetric flask. Use two small rinses of distilled water to transfer any remaining solution from the beaker to the volumetric flask. Dilute to the 10 ml mark. (Or, simply put lump of lithium in the volumetric flask in the first place and titrate it in the flask.)

Lithium chloride solutions prepared this way were sent to Oak Ridge National Laboratory for analyses (see Table N3).

Possible Analysis for Metallic Impurities in Lithium

Atomic Absorption Spectrophotometry

This method has not been tested. It may not be feasible for determining the metallic impurities in the lithium.

Obtain a lithium sample according to the procedure for ion-coupled plasma analysis. The following instructions are for a 0.5 gram lithium sample. Put the lithium in a 2 oz. plastic bottle. Titrate with concentrated HCl or HNO_3 to neutralize the lithium and determine its weight. Then acidify the resulting solution slightly (pH about 2) to keep insoluble hydroxides from forming. Dilute to 10ml. Measure the traces of metallic impurities by atomic absorption spectrophotometry.

The solubility of LiCl in cold water is about 6.5g/10ml (Weast, 1971) which will allow only 1g of Li to remain dissolved as a chloride (in 10 ml of water). Approximately the same amount of lithium will dissolve as the nitrate in water.

If the level of a metallic impurity in the lithium is 1 ppm, then the .5g sample of lithium will supply 0.5micrograms of the impurity to the 10ml final sample. The sample will, in other words, contain 0.05micrograms per ml. This is approximately the sensitivity (limit of detection) for some atomic absorption spectrophotometers.

Even at a 10 ppm level, the signal obtained in the analysis will be quite low. Further information about the atomic absorption method is provided in operating manuals such as that published by Varian (1969).

The UW Chemical Engineering Department has an atomic absorption spectrophotometer. The State Hygiene Lab also has an instrument.

The large amount of lithium present in the sample may interfere with analyses for the trace metals. Separation of these metals from the lithium may be necessary. Separation methods are available; for example, iron can be separated and concentrated by coprecipitation with a lanthanum hydroxide (Blaedel, 1976).

If a separation method is used, it may be convenient to use a larger amount of lithium in the first place, since the solubility of the lithium salts in a small volume of sample is no longer a limiting factor.

TABLE N1. LITHIUM ANALYSES FOR NITROGEN

Date of sample	Analyzed date lab	Weight* of tube	Molarity 100ml std	Titrant [m] : ml	Lithium weight,g	Analysis Result	ppm in Lithium	%variation or recovered
6/23/78	2/20/79ORNL	--	-- --	1.:14.23	1.975	11.5mv	484 N	15% variable
6/27/78	3/ /79ORNL	--	-- --	-- --	--	--	422 N	
1/10/79	2/20/79ORNL	--	-- --	1.:13.84	1.92	1.74mv	75 N	
2/8/79	not analyzed							
2/13	2/21/79ORNL	--	-- --	1.:12.64	1.74	1.05mv	50 N	1%variable
				1.:13.09	1.82	1.10mv	50 N	
	2/20/79ORNL	--	-- --	-- --	--	--	275 Oxygen by NAA	
7/13/79	9/21/79 UW	7.72g;1-27/32"	--	.106:36.35	2.67	43.2mv(4)	95 N	10%variable
		7.0 g;1-22/32"	--	.106:33.2	2.43	42.8mv(6)	106 N	
		--	1.038x10-4	-- --	--	ctl#1 56.4mv(3)		2%variable;
		--	1.038x10-4	-- --	--	ctl#2 55.7mv(5)		110%recovery
		--	1.038x10-4	-- --	--	std 57.1mv(1)		
		--	1.038x10-4	-- --	--	std 56.0mv(8)		7%variable
		--	1.038x10-4	-- --	--	std 58.5mv(9)		
		--	1.038x10-4	-- --	--	std 59.8mv(10)		
		--	1.038x10-2	-- --	--	std -56.0mv(2)		2%variable
		--	1.038x10-2	-- --	--	std -57.4mv(11)		

TABLE N1. continued LITHIUM ANALYSES FOR NITROGEN

Date of sample	Analyzed date	lab	Weight* of tube	Molarity 100ml std	Titrant [m] : ml	Lithium weight,g	Analysis Result	ppm in Lithium	%variation or recvry
8/9/79	not analyzed								
11/15/79	1/18/80	Soils	13.79g;2-1/8"	--	.1168:32.45	2.63	2.4ppmNH_4	72	12%variation
			12.66g;1-15/16"	--	.1168:30.36	2.43	2.0ppmNH_4	64	
			11.40g;1-3/4"	--	.1168:27.1	2.20	2.0ppmNH_4	72	
			--	.9495x10-4	-- --	-- ctl	1.6ppmNH_4	--	94%recovery
			--	.9495x10-4	-- --	-- ctl	1.2ppmNH_4	--	70%recovery
1/15/80	1/18/80	Soils	8.30g;1+1-1/16"	--	.1168:35.31	2.86	3.4ppmNH_4	93	12%variation
			5.63g;21/32;3/4"	-	.1168:25.58	2.06	2.8ppmNH_4	105	
2/25/80	4/11/80	Soils	5.05g;1-1/4"	--	.118 :20.5	1.67	1.4ppmNH_4	65	3%variation
			6.15g;1-1/2"	--	.118 :27.0	2,21	1.8ppmNH_4	63	
4/8/80	4/11/80	Soils	4.19g;1"	--	.118 :17.11	1.4	1.4ppmNH_4	78	3%variation
			9.36g;1-3/16+1-3/32"		.118 :39.5	3,23	3.3ppmNH_4	80	
				2ml:.0172	-- --	-- ctl	3.8ppmNH_4	--	86%recoverv
				2ml:.0172	-- --	-- ctl	3.6ppmNH_4	--	81%recovery
						blank	<0.2ppmNH_4		
						blank	<0.2ppmNH_4		

TABLE N2. ANALYSES FOR METALS IN LITHIUM: DETERMINATION OF LITHIUM WEIGHT

Date of Sample	Analysis* date lab	Li weight (balance)	HCl Titrant normality	HCl Titrant volume	Li weight by titration	Iron** content
8/9/79	2/80 ORNL	----	1.168	8.45ml	0.068g	30ppm$_w$
11/15/79	2/80 ORNL	----	1.168	4.73ml	0.038g	5ppm$_w$
1/15/80	2/80 ORNL	----	1.168	5.62ml	0.045g	10ppm$_w$
	4/17/80 Soils	1.1013g	11.8	15.94ml	1.304g	3.7ppm$_w$
2/25/80	4/17/80 Soils	1.2236g	11.8	15.90ml	1.30 g	3.3ppm$_w$
		1.2104g	11.8	17.40ml	1.423g	2.7ppm$_w$
4/8/80	4/17/80 Soils	1.1275g	11.8	14.38ml	1.108g	4.8ppm$_w$
		1.3654g	11.8	18.70ml	1.53 g	3.1ppm$_w$
------	4/17/80 Soils	----	---	-----	blank	0.45ppm$_w$
		----	---	-----	blank	0.55ppm$_w$

* ORNL analyses by DC arc spectrograph; UW Soils Lab analyses by Ion-coupled plasma spectrophotometry.

** Including any blank. Blank estimated at 1.25ppm based on 1 gram lithium sample. Analyses based on lithium weight determined by balance, not titration.

TABLE N3a. ANALYSES FOR METALS IN LITHIUM FROM LOOP

Spectrographic analyses by Oak Ridge National Laboratory. Semi-quantitative analyses; the values reported are visual estimates taken from a standard plate and using a common graphite matrix. These values are to be interpreted as approximations only. Actual value should be within the range times 1/2 to times 2.

August 9, 1979 lithium sample weighed .068g(UW) 6.70mg/ml(ORNL)
November 15,1979 .0382g 3.75mg/ml
January 15,1979 .0454g 4.60mg/ml

Log 3542 plate E7174 request 31415 2-28-80

Metal	August(450-350C)	November(500-325)	January
Ag	<.1	<.1	<.1
Al	60	50	100
Au	<10	<10	<10
B	40	20	25
Ba	<5	<5	<5
Be	<1	<1	<1
Bi	<2	<2	<2
Ca	45	40	50
Cd	<10	<10	<10
Co	<10	<10	<10
Cr	<2	10	4
Cu	8	8	8
Fe	30	5	10
Ga	<2	<2	<2
Ge	<5	<5	<5
In	<2	<2	<2
K	30	30	30
L	Major	Major	Major
Mg	15	15	15
Mn	20	20	20
Mo	<2	<2	<2
Na	100	70	80
Nb	<10	<10	<10
Ni	<5	<5	<5
Pb	3	3	3
Rb	<2	<2	<2
Sb	<20	<20	<20
Si	200	200	150
Sn	<2	<2	<2
Ta	<10	<10	<10
Ti	20	<5	<5
V	<5	<5	<5
W	<10	<10	<10
Zr	<15	<15	<15

TABLE N3b. ANALYSES FOR METALS IN LITHIUM FROM LOOP

Ion-coupled plasma analyses by University of Wisconsin Soils Laboratory, 802 South Park Street, Madison, Wisconsin. All lithium from 500-325C loop. Values in weight ppm based on lithium.*

Metal	January 15,1980	February 25		April 8		Blanks*	
Copper	3.3	3.0	3.1	2.7	3.0	.27	.26
Nickel	8.1	6.0	5.7	7.2	6.5	LT.037	
Chromium	3.0	2.4	2.3	2.4	2.3	LT.017	
Lead	11	9.7	9.5	9.4	8.4	.157	.148
Cadmium	1.5	1.6	1.5	1.6	1.5	LT.010	
Zinc	7.8	6.3	6.0	7.8	5.7	.094	.098
Molybdenum	2.2	1.8	1.9	1.8	1.6	LT.021	
Cobalt	4.1	3.7	3.8	3.8	3.4	LT.018	
Iron	3.6	3.3	2.7	4.8	3.1	.045	.055
Aluminum	46	40	41	40	36	LT.035	

* Blank values micrograms per ml of distilled water with 2 drops indicator added.

LT indicates "less than"

STAINLESS STEEL COUPON ANALYSES

Mounting the coupon for microscope work

The following technique has been used for coupons examined on the electron microprobe and on the light microscope. Refer to Figure N1.

a. If desired, nickel plate the coupon to provide extra protection of the surface layer against being "rounded over" during the polishing. A rounded edge will not come into good focus.

b. Hold the coupon between aluminum shims in a vise. Cut two circular slices about 3/16" each off the unnumbered end of the coupon.

c. Cut the remainder of the coupon into four longitudinal pieces.

d. If desired, drill small holes in two of the long sections (preferably those with the number identification intact) and tie these two pieces and one circular section together with stainless wire. Store in alcohol.

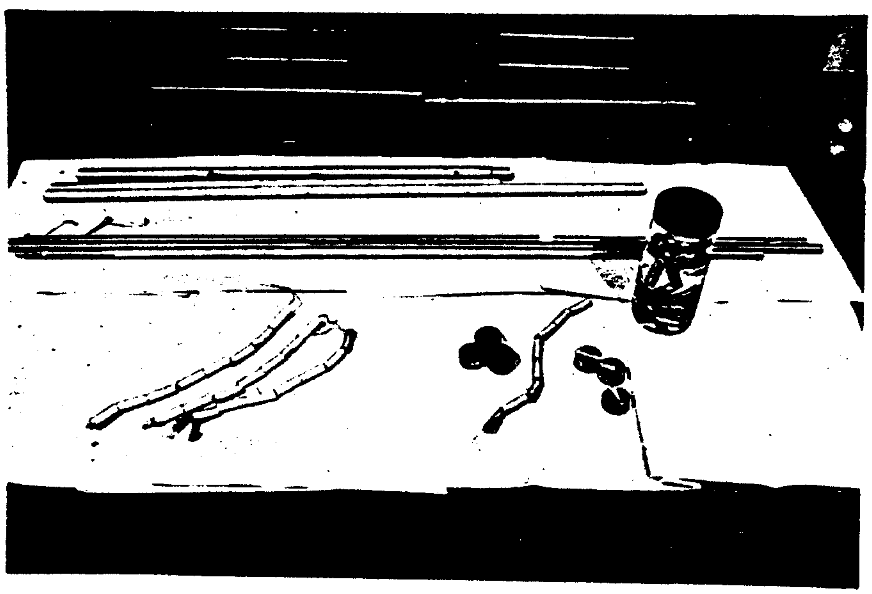
e. Place one of the circular sections cut-end down inside a plastic "cap-seal" container.

f. Wrap stainless steel wire (approximately .02" diameter) around one end of each of two long pieces. Two or three turns is all that is needed; no more should be used.

g. Place one of the long pieces, with an unscratched inner surface, inside-down next to the circular section.

h. Place the other long piece, with an unscratched outer surface, outside-down next to the other long piece. Make sure the wire-wrapped ends are both at the same side.

i. Print or type the identifying number and any pertinent information about the coupon on a slip of paper about 1/4" wide. Put this paper, printed side out, inside the capseal.



COUPONS, AS-RECEIVED AND EXPOSED-TO-LITHIUM;
STORED IN ALCOHOL OR MOUNTED FOR MICROSCOPY.

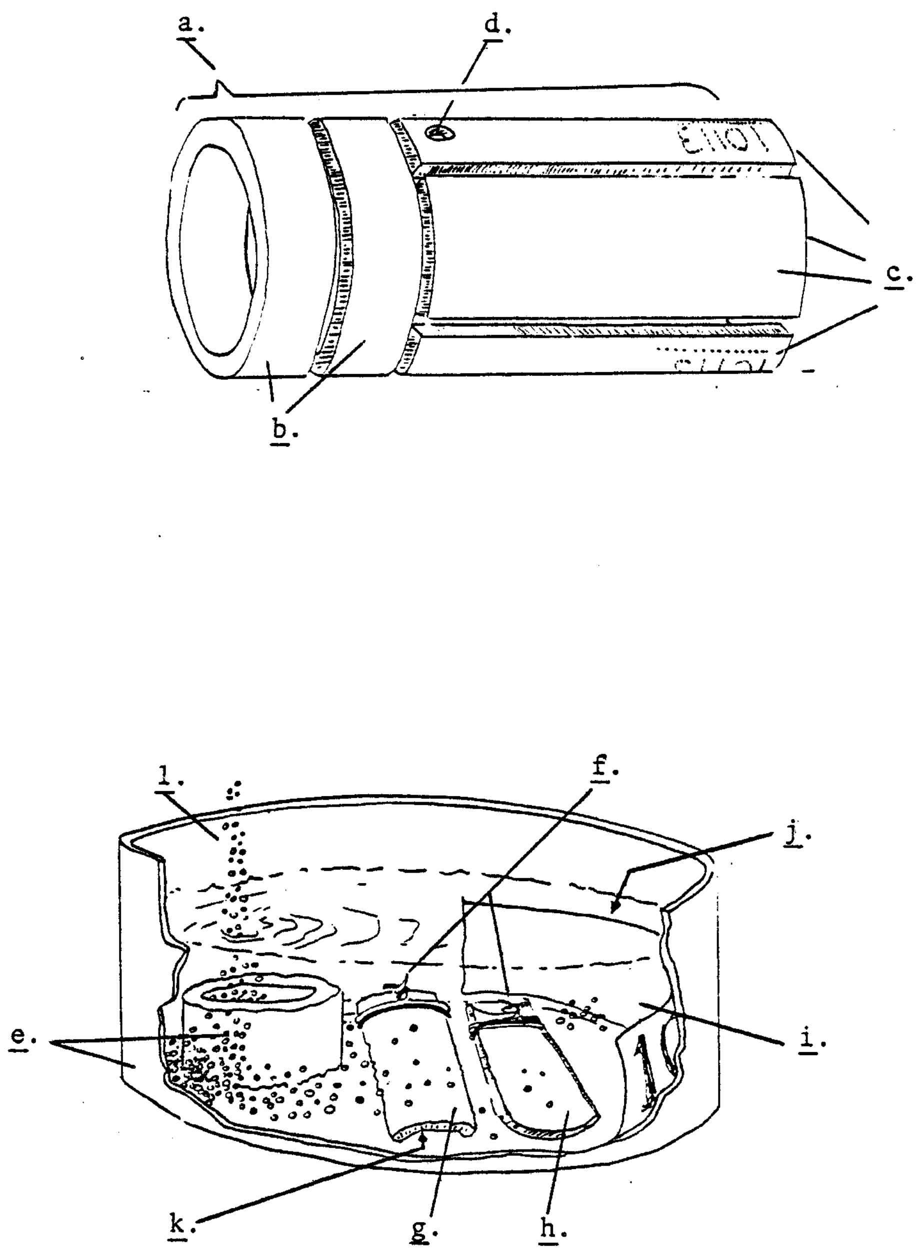


FIGURE N1. MOUNTING COUPONS FOR MICROSCOPY

j. Pour epoxy glue into the capseal to completely cover the coupon sections (1/2-3/4" deep).

k. Immediately after pouring the epoxy, lift the coupon sections to allow the glue to flow under them. Also make sure the identification paper is coated on both sides and is near the edge of the mount so it will be easy to read.

l. Sprinkle iron beads (about 1 mm diameter) over the coupon sections to a depth of about 1/4". These will provide additional resistance to the abrasives' action during polishing, so that the epoxy is not removed too much faster than the stainless steel. Make sure to get the iron beads inside the circular section, but don't put any under the longitudinal sections.

m. After the epoxy has set completely, pop the mount out of the capseal.

<u>Polishing the mounted coupons</u>

Refer to Figure N2. All sanding and polishing must be done with the mount wet with water.

a. Use a power-driven abrasive belt to rough sand the mount until the exposed circular section is (at least almost) free of saw cuts and the two longitudinal sections are sanded only enough to show both the inside and outside wall.

b. The polished surfaces must all be in the same plane.

c. The polished surface need not be exactly normal to the axis of the mount, but should be approximately so in order to allow mounting in the microprobe.

d. Grind the sample by hand now with progressively finer sandpaper, ending with 600 grit paper. This hand grinding ing should not take more than five or ten minutes. Finally, use a power driven polishing wheel and .03 micron or smaller abrasive grit slurry to finish polishing the sample to a mirror finish without scratches.

e. Measure the polished lengths "A" and "B". The coupon wall thickness is close to 0.035"; the polishing method causes an apparent increase in this distance by a factor of A/.035" and B/.035", for the two samples. These factors apply only along the center of the "vee" formed by the polishing. For instance, if A is measured as .35", the factor for that coupon is .35/.035=10X. If there is a 1 micron thick ferrite layer on the coupon, it will appear to be 10 microns thick (but only along the center of the "V"). The magnification factor (due to polishing) does not apply to the circular section, which is polished at right angles to its surface.

f. If the sample is subsequently etched, saw a fine, shallow groove across the reverse side to indicate that it has been etched. It may be desirable to keep etched samples in a dessicator.

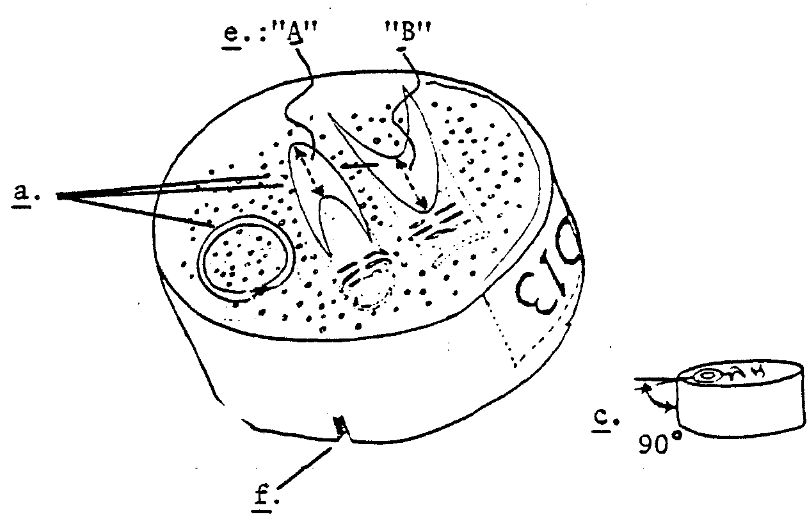


FIGURE N2. POLISHING THE MOUNTED COUPONS

Optical microscopy

A Zeiss optical microscope with provision for photomicrography is available on the 11th floor of the Engineering Research Building. (Materials Science Department). Magnifications of up to 1000X are possible. Magnifications of 400X or less have been used in the present work. Photomicrographs of coupons are shown in the Results chapter (V) of the thesis.

An etch (such as 12 parts glycerine, 25 parts HCl and 5 parts HNO_3, by volume; to attack the ferrite) may be used to differentiate any ferrite from the original austenite phase of the 316 stainless steel. Care just be used in preparing the etch mentioned above; mix the HCl and glycerine first, before adding the HNO_3--- or nitroglycerine may be formed. (OR use a different etch.)

Apply the glycerine-HCl-HNO_3 etch by swabbing the sample with it. Two minutes or more time may be used; shorter times may also give desired results. Rinse the sample well with running water. Discard the etch when it turns orange (Mack, 1980).

Scanning electron microscope

Scanning electron microscopes are available on the 11th floor of the Engineering Research Building (Materials Science Department) and in Weeks Hall (Geology Department).

The scanning electron microscope would provide higher magnification than the optical microscope. Its use requires more set-up. The SEM might be used to study the surface of unpolished coupons.

For polished coupons, the Geology SEM has an automatic line-scan for up to four elements, but the scan duration seems too short for quantitative analyses; the signal-to-noise ratio may be high. Perhaps this line scan capability can be optimized for better results. The beam size of the SEM is about 0.1 microns, considerably better (smaller) than the beam size of the microprobe. Scanning electron micrographs of some of the coupons are shown in Figures V5 and V6 in chapter V of the thesis.

EDAX (Energy Dispersive Analysis by X-rays)

EDAX measurements were made of some of the coupons. The coupon surface compositions are shown in Table N4. (The scanning electron micrographs and the EDAX analyses are courtesy of the Westinghouse company).

TABLE N4 . COUPON SURFACE COMPOSITIONS BY EDAX

Coupon		Weight percentages of these elements: Fe	Cr	Ni	Mn	Mo	Si
12308X							
as-received	OD	65.74	17.46	9.19	3.43	2.95	1.22
12408X							
as-received	OD	65.38	17.71	9.54	3.60	2.53	1.25
	ID	64.84	17.96	9.19	3.32	2.62	0.93
12415							
490C/2 mo.	OD	85.11	6.21	7.42	0.76	-.--	0.49
1 m/s	ID	72.04	10.65	14.05	1.01	-.--	0.22
	ID spot*	87.47	7.83	2.18	0.74	-.--	0.24
	ID spot*	86.02	8.71	2.02	1.04	0.44	0.25
12315							
490C/2 mo.	OD	84.99	11.32	1.04	1.50	0.49	0.66
0.3 m/s	ID	88.58	7.50	1.71	0.60	-.--	-.--
Coupon		**Atomic percentages of these elements: Fe**	**Cr**	**Ni**	**Mn**	**Mo**	**Si**
12308X							
as-received	OD	65.17	18.59	8.67	3.46	1.70	2.41
12408X							
as-received	OD	64.67	18.81	8.98	3.62	1.45	2.46
	ID	65.08	19.36	8.78	3.39	1.53	1.86
12415							
490C/ 2 mo.	OD	84.60	6.63	7.01	0.77	-.--	0.98
1 m/s	ID	73.27	11.64	13.59	1.05	-.--	0.45
	ID spot*	88.19	8.48	2.09	0.76	-.--	0.49
	ID spot*	86.80	9.44	1.94	1.07	0.263	0.51
12315							
490C/ 2 mo.	OD	83.92	12.01	0.98	1.51	0.28	1.30
0.3 m/s	ID	89.59	8.14	1.64	0.62	-.--	-.--

*spots on 12415 not covered by second phase.

Analysis of coupons by electron microprobe

The current work utilized the Applied Research Laboratories (ARL) electron microprobe, model EMX, located at Weeks Hall (UW Geology Department). Recommended operating procedures are given by Glover (1980).

A standard mount containing pure iron, chromium, nickel, manganese and molybdenum standards along with a fluorescent salt (to emit visible light and aid in focussing the electron beam) is placed in the sample chamber with up to seven samples. These samples may include polished coupons that have or have not been exposed to lithium. Do not attempt quantitative microprobe analyses of etched coupons. The etch may have preferentially removed some elements.

When focussing the electron beam on the salt crystal, note the beam position with respect to the scale on the microscope eyepiece, for later reference during analyses.

Quantitative analyses of a given point (2-3 microns in diameter) or area (variable size) may be made in the "point" or "area" modes. All results should be compared to pure element standards. Up to two elements may be determined simultaneously; additional elements may be measured at the same point or area by changing the wavelength setting on one or both of the two detectors. The results of these "point" or "area" fixed wavelength analyses can be output on digital meters, typewriter, or computer card-punch.

The microprobe will also automatically scan all wavelengths at a given location on the sample, yielding an X-Y plot of energy versus wavelength, which can be examined to see the presence of a spectrum of elements.

In order to obtain a "line-scan" profile at a fixed wavelength (that is, the profile of a single element) the beam may be slowly moved in a single, variable length"line"in the x or y direction, with the resulting energy vs. distance output on the X-Y plotter.

Perhaps the most straightforward method for obtaining a quantitative line scan is to use the microprobe in the "point" mode and move the sample stage beneath it in small (e.g. 1 or 10 micron) steps. The x and y verniers on the stage control are graduated in microns. The probe can count for a preset time or total number of counts at each point, writing the results on the typewriter and on punched cards. If small steps are taken, this manual line scan can be slow, but it allows more information to be taken at a given point than does the automatic line scan. Furthermore, a long traverse across the sample is allowed, since the sample stage can be moved furthet than the electron beam can accurately be deflected. The user must be careful of backlash in the stage controls by moving the verniers only in one direction during the scan.

Several closely spaced parallel scans should be made at each region of interest. The results of each point along these scans should be typed out and punched on computer cards (done automatically by the microprobe).

The location of the beam in the "point" mode is approximately the point at which it was originally focussed; an update on the beam position can be obtained between scans by moving the sample and seeing the crater burned in the epoxy by the beam. The size of the crater or gouge also shows an upper bound on the beam size.

Computer programs are available at the UW Madison Academic Computing Center for analyzing the microprobe data contained on punched cards. The UW Geology Department has information on these programs (Glover, 1980).

All coupon analyses should be based against pure metal standards analyzed under the same conditions. It is advisable to analyze the standards and coupons during the same work session. This requirement is not quite so important if one merely wishes to compare the ratio of two metals at different points in the same coupon.

Point by Point Line Scan on Two-Channel Microprobe

1. An accelerating voltage of 15Kv and a beam current of approximately 0.03microamperes are used. At each sample point, a total of 10,000 counts are taken. This requires 5 - 10 seconds.

2. Set the beam in "point mode." Set one detector on the iron K-alpha wavelength. Alternate the second detector between the chromium and nickel K-alpha wavelengths.

3. All microprobe data is automatically typed and keypunched as it is generated. With each new standard or sample scan, write the time of day and identifying information on the first card punched, and typed it (in manual typewriter mode) on the typewritten page.

4. At the beginning, end, and at two-hour intervals during each microprobe work session, a.) check the beam focus on the fluorescent crystal, and adjust it if necessary to give the smallest spot size; b.) take replicated counts at four different places on each of the pure iron, chromium and nickel standards.

5. To perform the actual line scan, for either Fe & Cr or for Fe & Ni;

a.) Position the stage so that slow turning of the x-axis drive knob moves the sample past the electron beam, perpendicular to the sample edge and going into the sample. Note the x setting (microns) at which the counting rate suddenly increases. This is approximately the edge of the sample. Back off and advance the x axis knob several times to get a good fix on the edge.

b.) Back off one full turn of the x knob and then advance the knob to within 20 microns of where the sample edge will be encountered. From now on do not reverse the direction of movement or backlash will result. Do not touch any stage control except the x-drive.

c.) Count the x-rays at this point, then have them typed and key-punched before advancing the stage. If the typewriter or key-punch malfunctions, retake the count at this point.

d.) Advance the x drive, always in the same direction, 2 microns at a time. (Larger steps may be taken with samples polished at an angle.)

e.) Count x-rays again at next point. At every fifth point, advance the typewriter one line for clarity, and (manual mode typing) type the point number and x-drive setting.

f.) After the counts stabilize at the bulk phase composition, increase the step size to 10 microns for 3 steps and then to 100 microns for 2 or 3 steps.

g.) A line scan of 30- 40 steps is made without changing the detector settings. When the scan is completed, the second detector can be changed to the other metal (either nickel or chromium) and the line scan repeated for iron and the that metal.

Microprobe line scans of coupons are shown on Figures N4.
See also graphing program PROBE in Appendix T.

Auger microscopy

Auger (pronounced o-zshay') microscopy is largely a surface-sensitive measurement. However, many Auger systems have an argon ion beam for sputtering away the surface layers for "ion-probe mass spectrometry." This wearing away of the surface layers gives a depth profile of the elements of interest. Such a profile is similar to the microprobe line-scan except that the Auger moves into the metal from the surface, and the microprobe moves across a polished section of the sample.

Ion-sputtering is rather slow.

There is an Auger system on the 12th floor of the Engineering Research Building (Materials Science Department). It incorporates an ion-sputtering system.

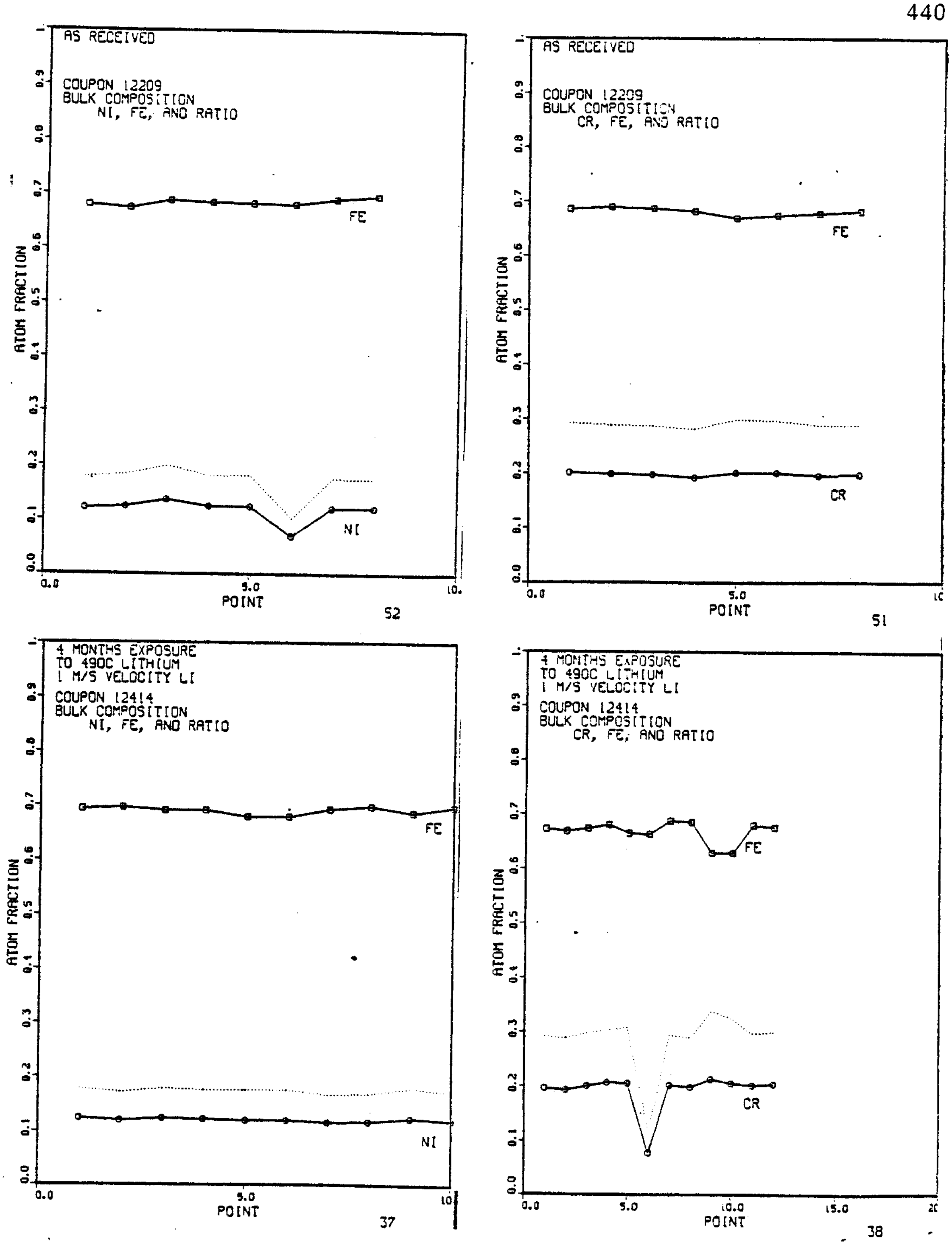


Figure N3a. Microprobe data--bulk composition.
Top: As-Received coupon.
Bottom: 4 mo. lithium at 490C and 1 m/s.

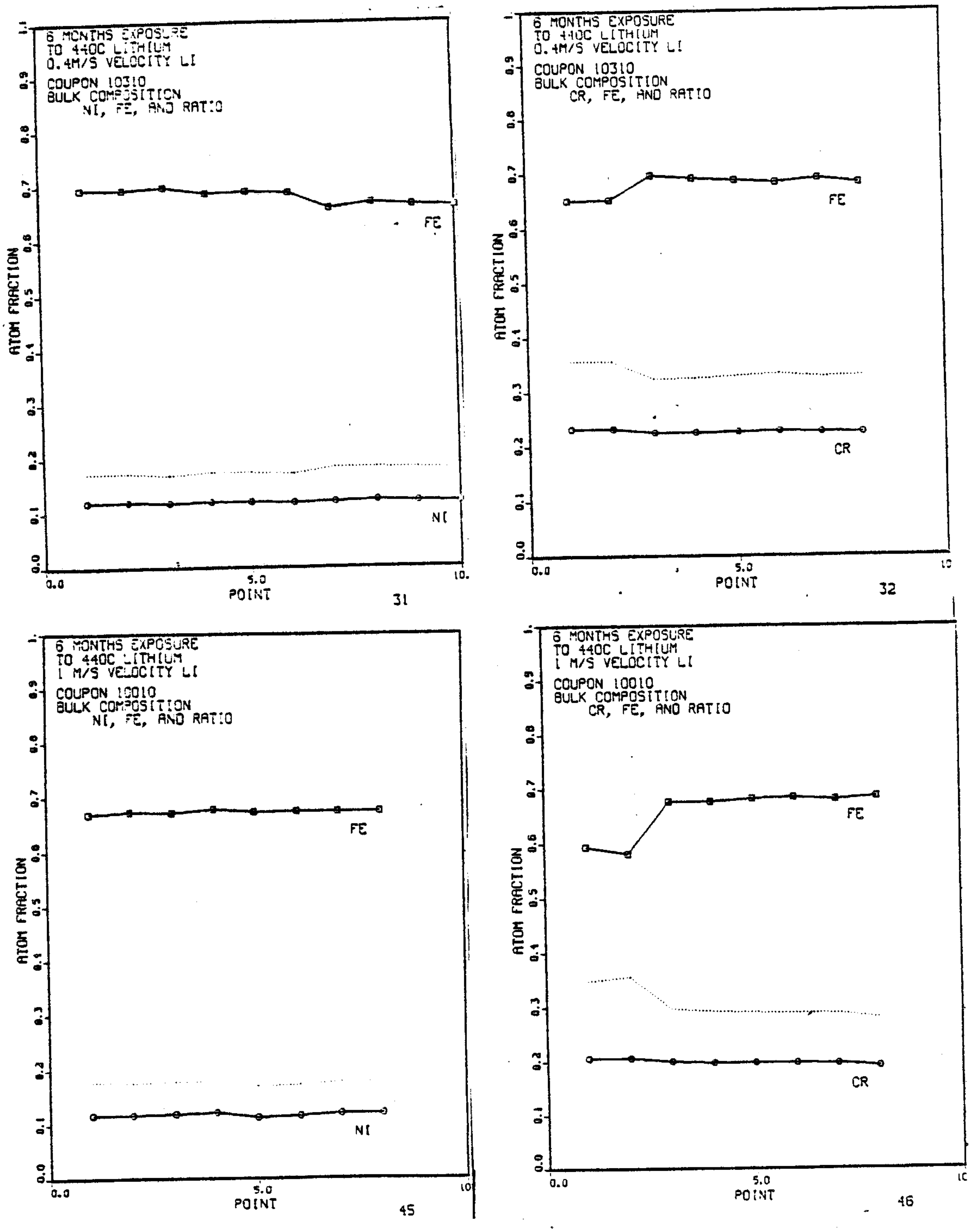


Figure N3b. Microprobe data--bulk composition.
Top: 6 mo. lithium at 440C and 0.4m/s.
Bottom: 6 mo. lithium at 440C and 1.0m/s.

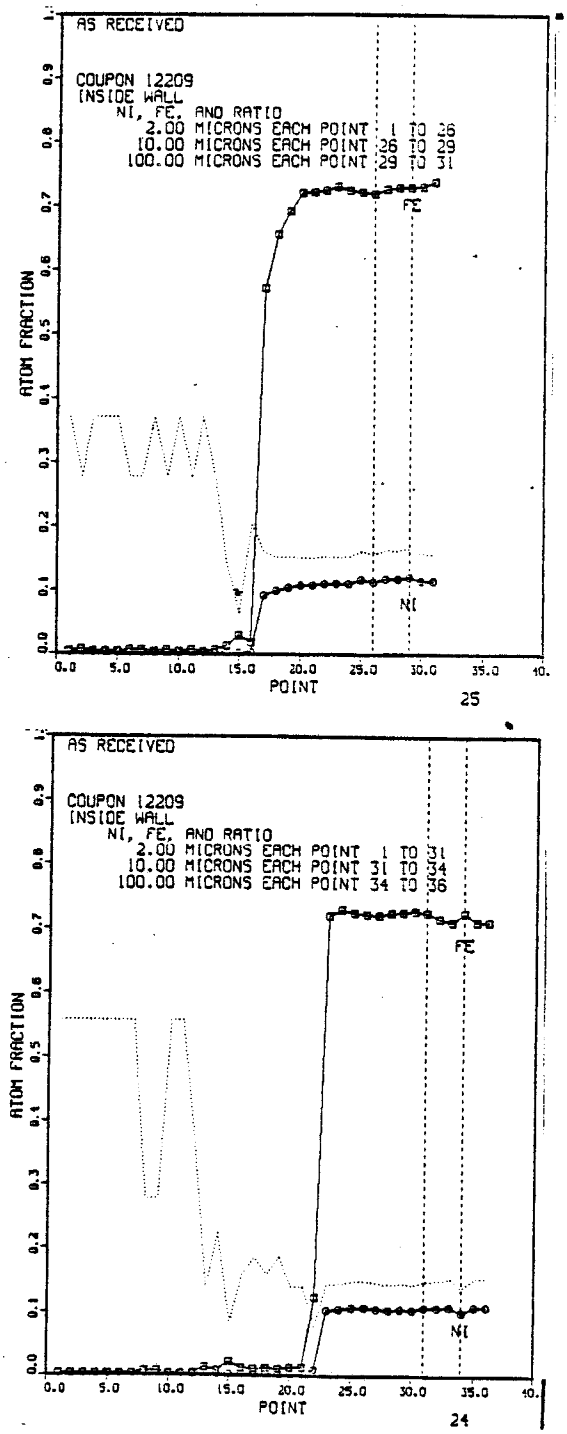
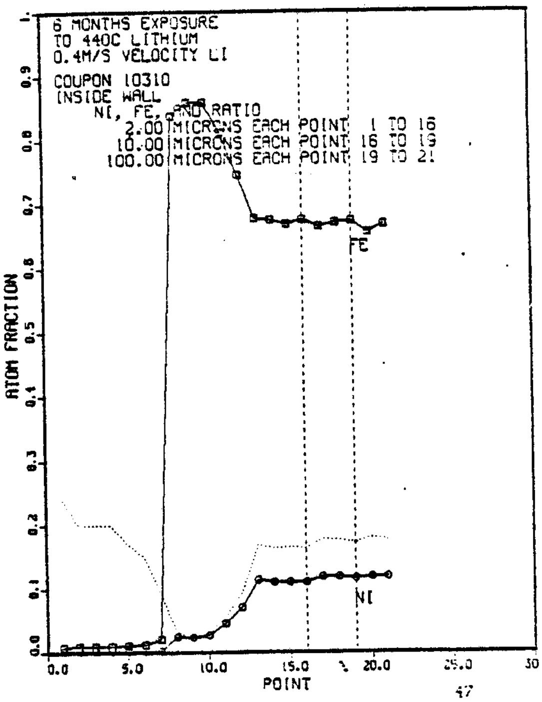
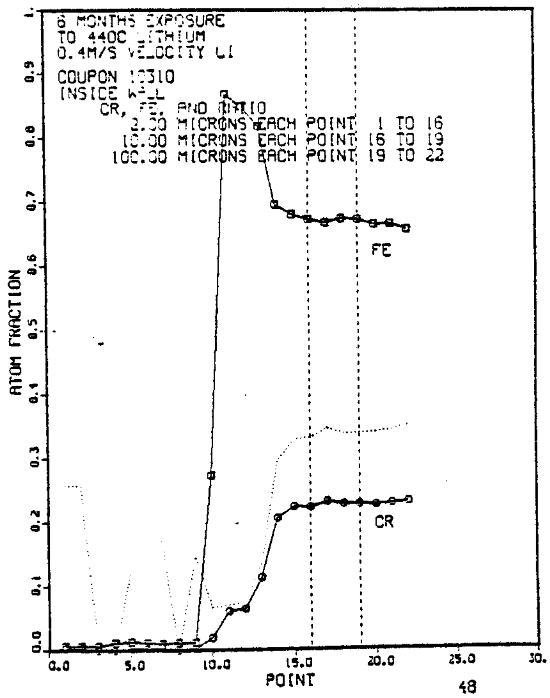
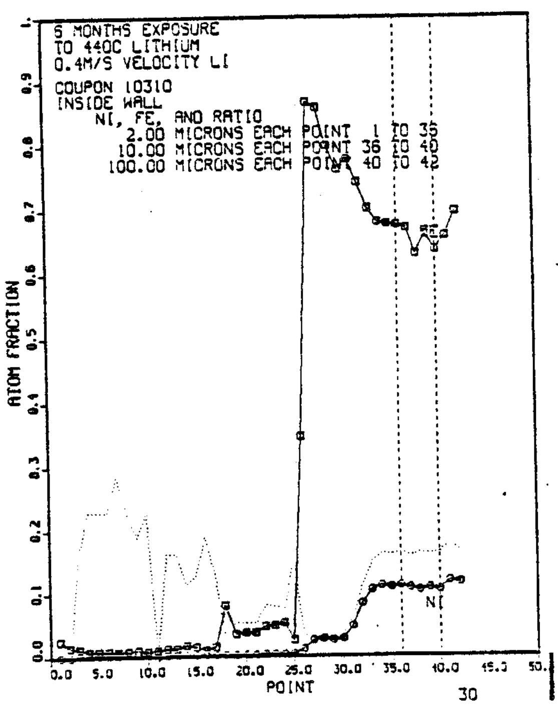


Figure N3c. Microprobe composition profiles.
As-received coupon, inside wall.







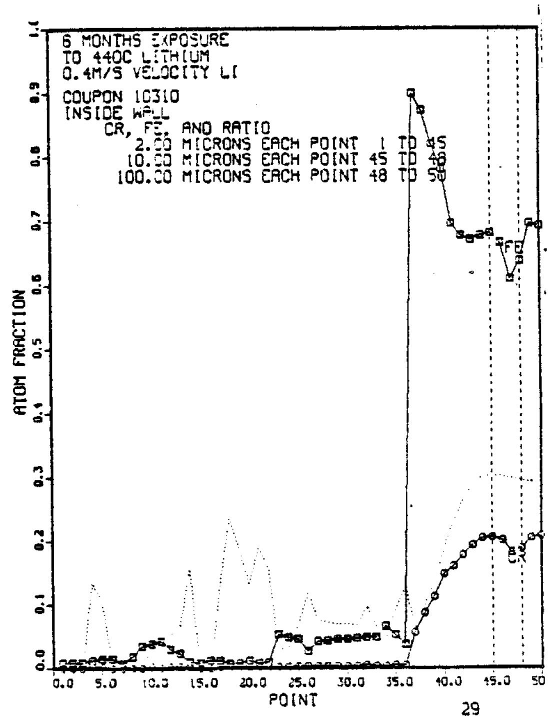


Figure N3d. Microprobe composition profiles.
6 months exposure to lithium
at 440C and 0.4 m/s. Inside wall.

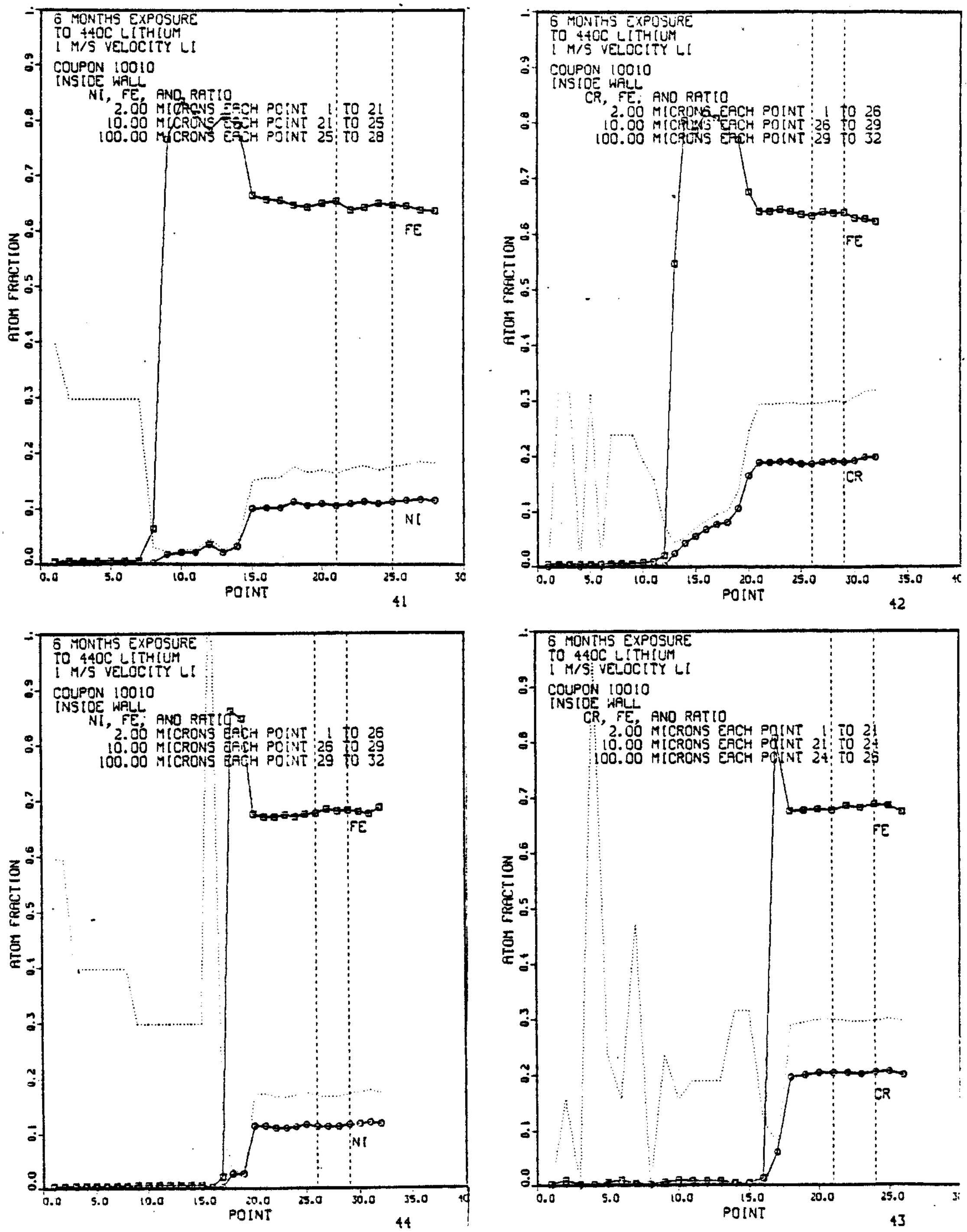


Figure N3e. Microprobe composition profiles
6 months exposure to lithium
at 490C and 1.0 m/s; inside wall.

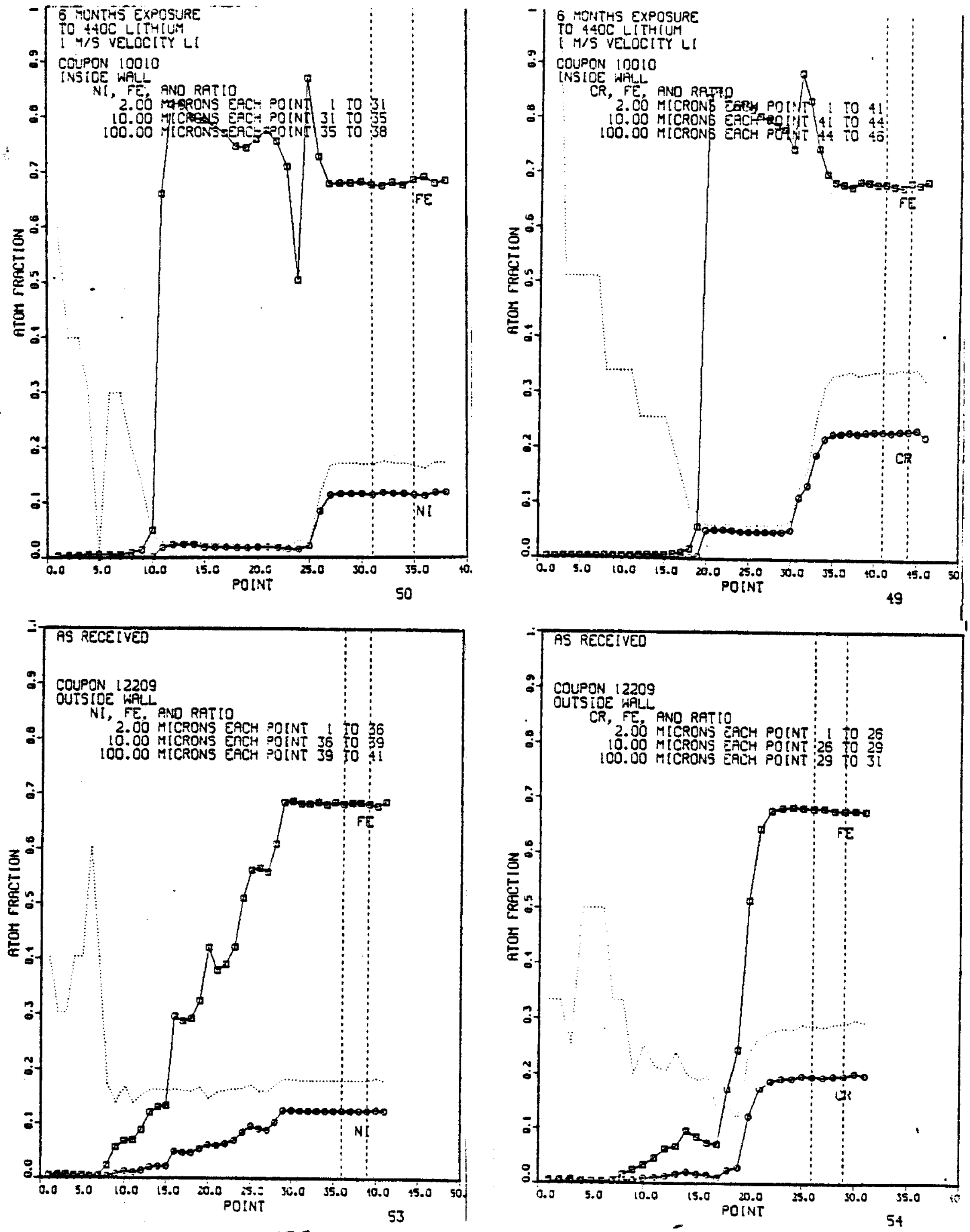


Figure N3f. Microprobe composition profiles
Showing non-smooth profiles.
Top: 6 months in lithium at 440C and 1.0m/s.
Bottom: As-received, outside wall.

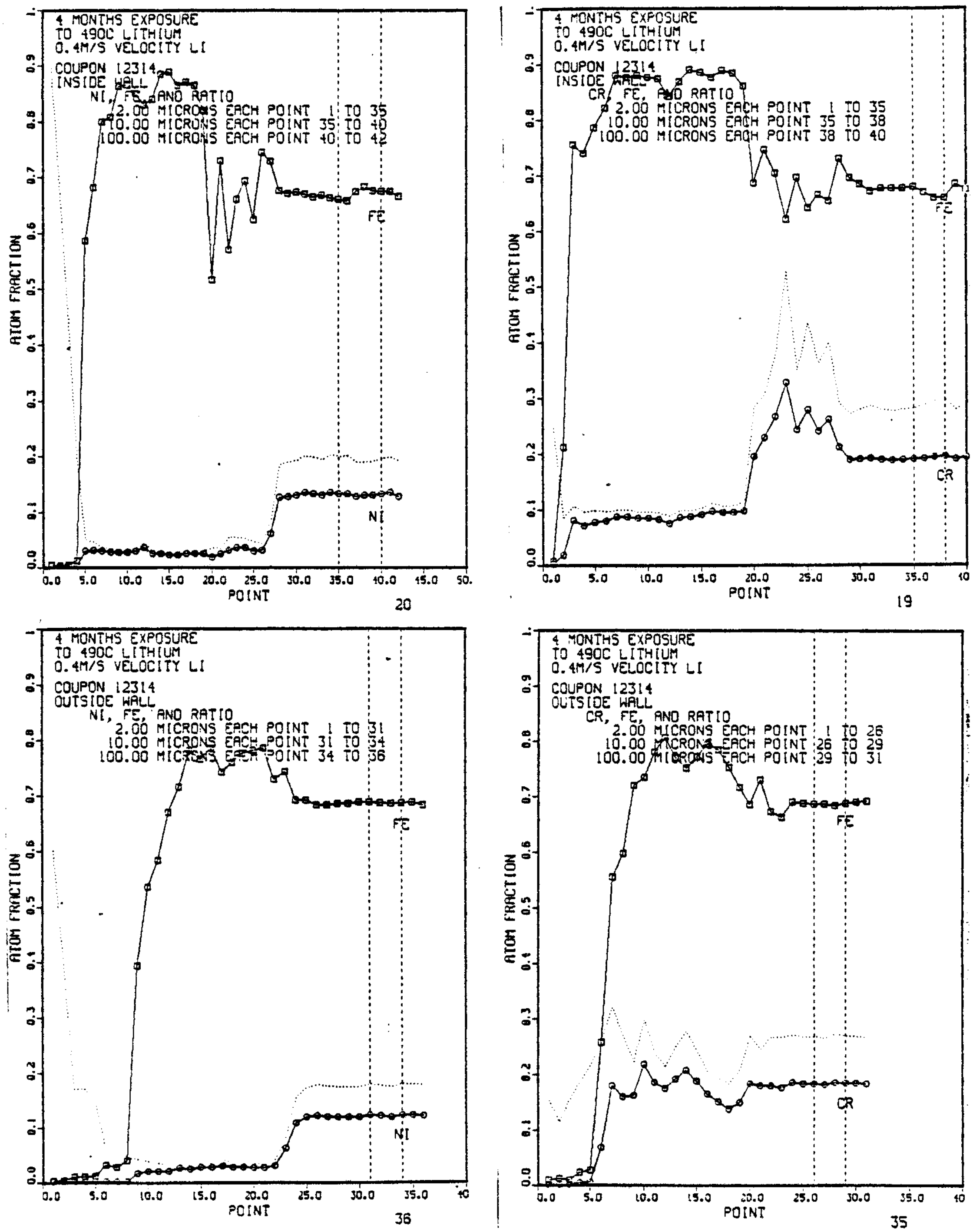


Figure N3g. Microprobe composition profiles
4 months exposure to lithium at
490 C and 0.4 m/s; inside and outside walls.

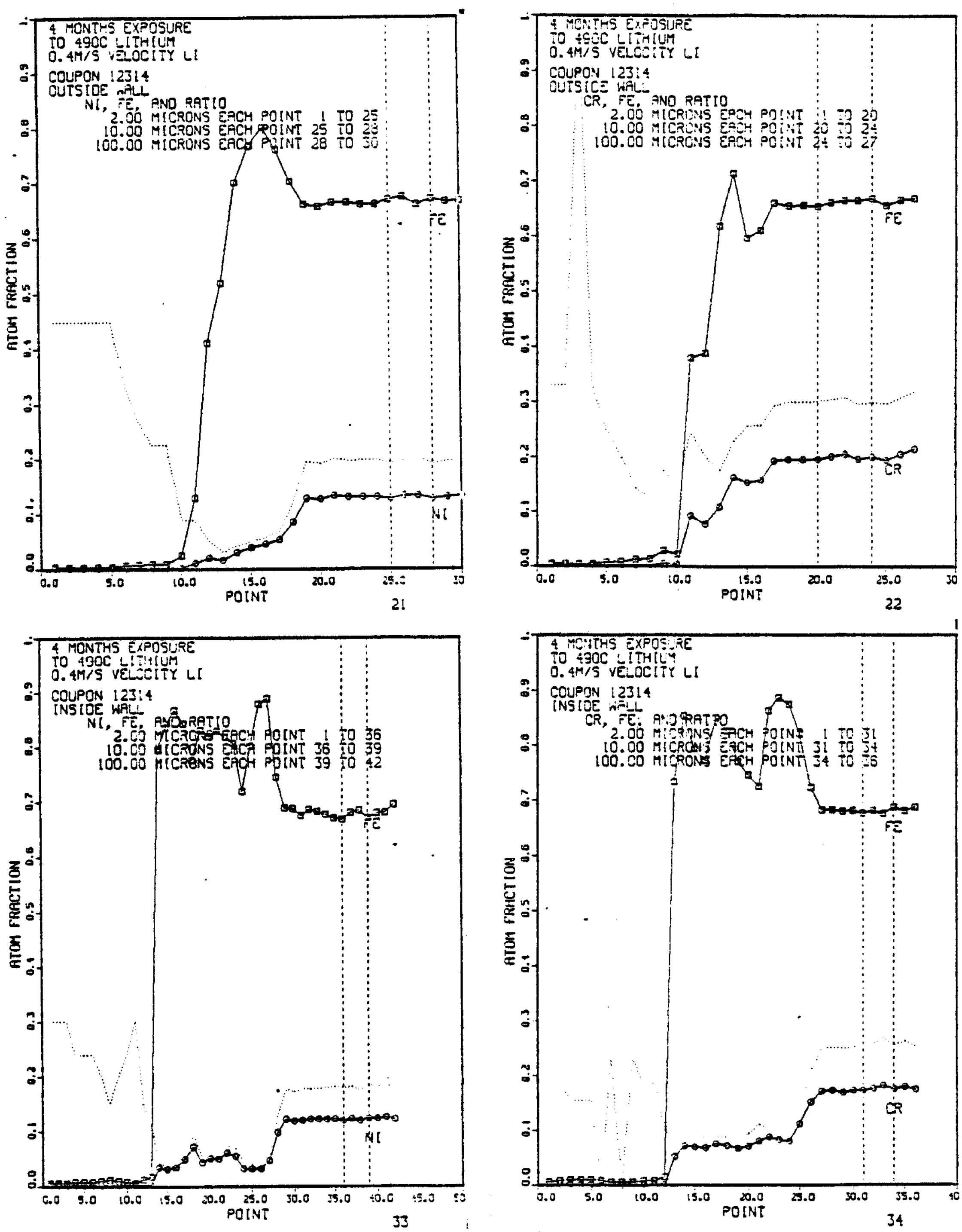


Figure N3h. Microprobe composition profiles
4 months exposure to lithium at
490 C and 0.4 m/s; outside and inside walls.

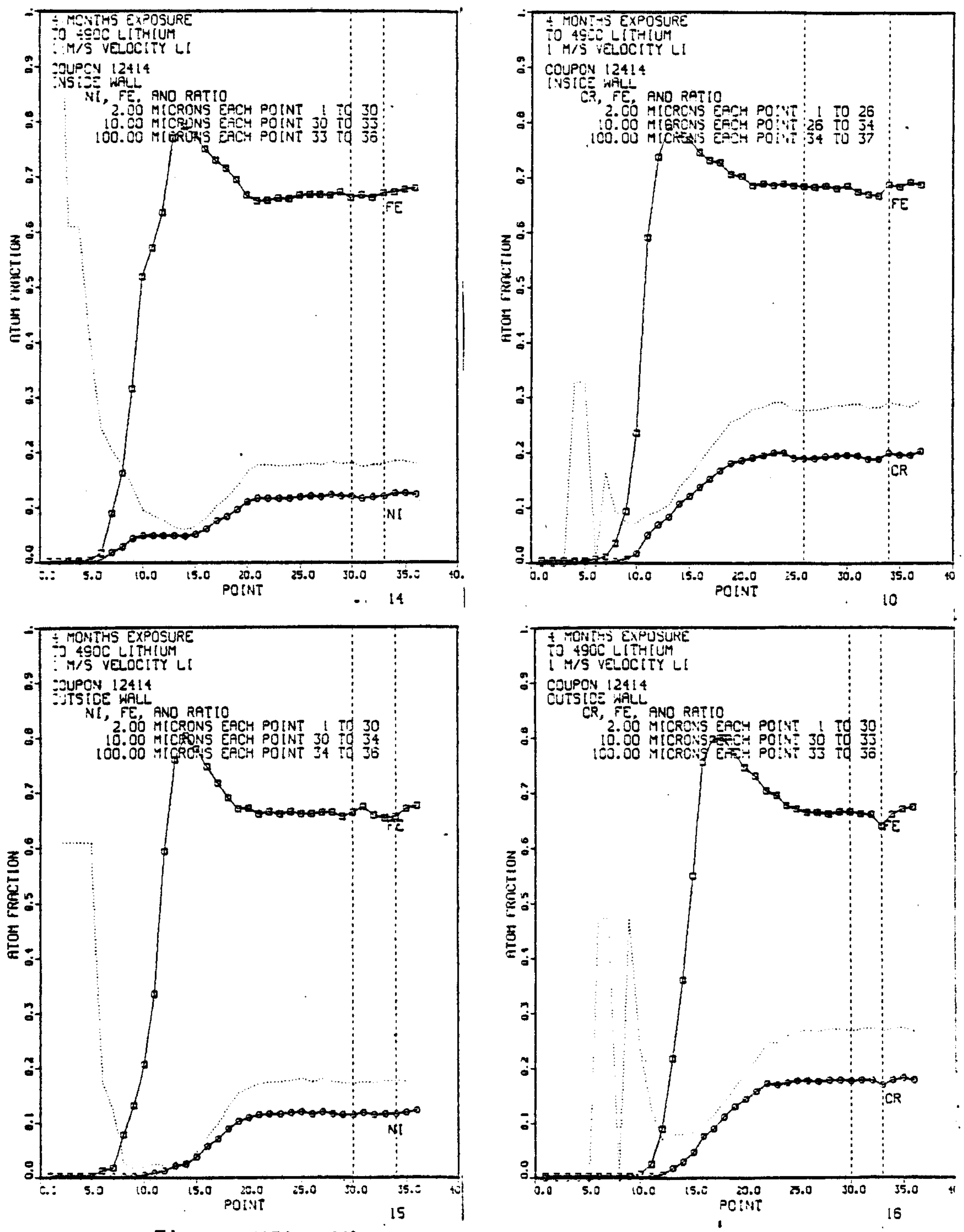


Figure N3i. Microprobe composition profiles
4 months exposure to lithium at
490 C and 1.0 m/s; inside and outside walls.

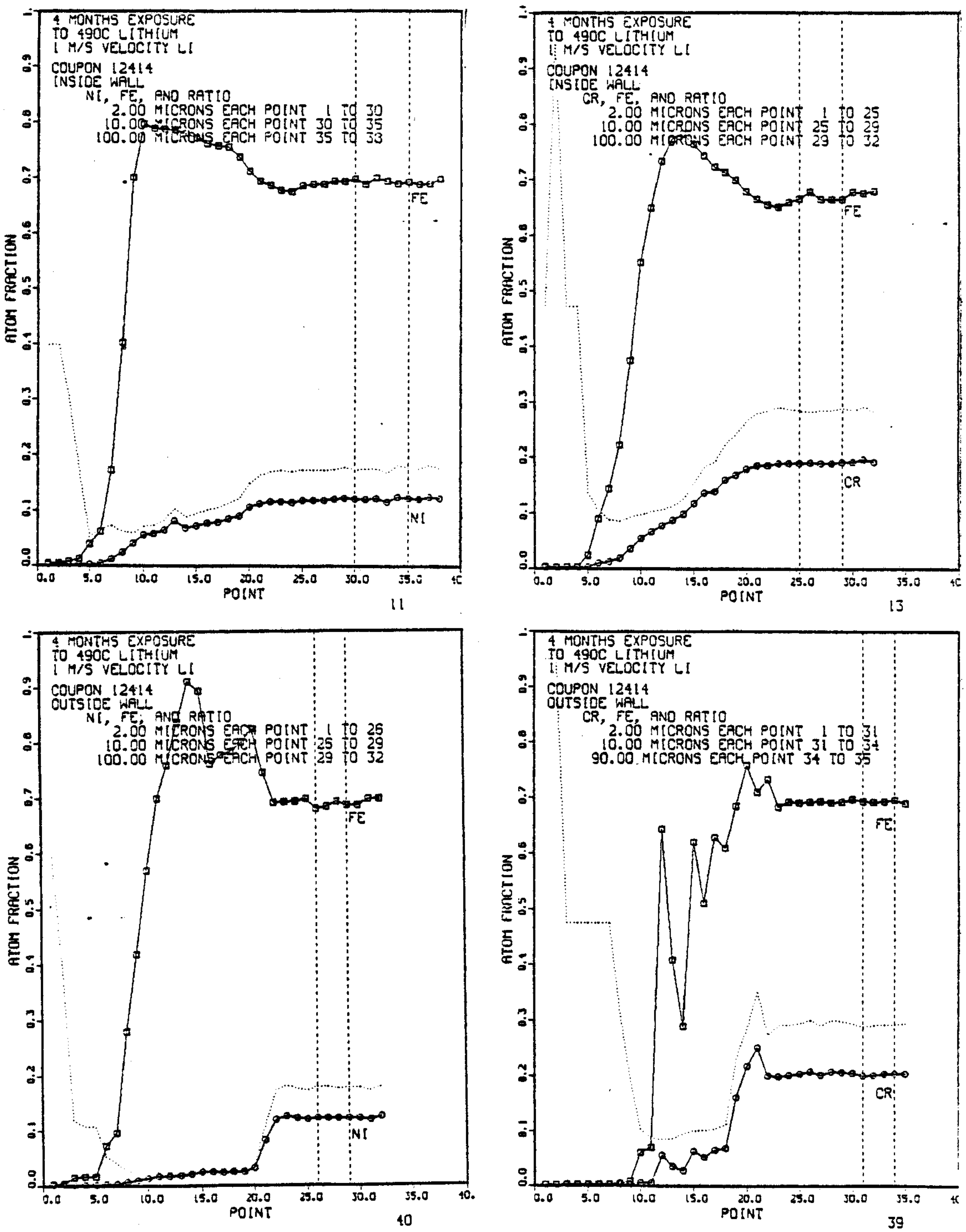


Figure N3j. Microprobe composition profiles
4 months exposure to lithium at
490 C and 1.0 m/s; inside and outside walls.

APPENDIX O. FLOWMETER CALIBRATIONS

Procedure

Program METERS

Flowmeter calibrations [5-15ff]

The lithium flowrate through the four flowmeters, $\dot{m}$, is the total lithium flowrate in the loop

$$\dot{m} = \pi r^2 \rho \,(mv_1 k_1 + mv_2 k_2 + mv_3 k_3 + mv_4 k_4) \qquad (1)$$

where: mv_i is the millivoltage output from meter i
k_i is the velocity per millivolt calibration factor for meter i
r is the flowmeter tube inside radius
ρ is the density of the lithium

The flowmeters may be calibrated by thermal (energy) balance or by drain (mass) balance. The rate of energy input E to the total lithium flow $\dot{m}$ is

$$E = \frac{V \times I}{4.187} = \dot{m}\, C_p\, (T_2 - T_1) - U\, A\, \left[\left(\frac{T_2 + T_1}{2}\right) - T_a\right] \qquad (2)$$

where: V is the voltage across the main heater
I is the current through the main heater
C_p is the heat capacity of the lithium
T_2 is the lithium temperature at heater exit
T_1 is the lithium temperature at heater inlet
T_a is the ambient temperature
U is an overall heat transfer coefficient
A is the area for heat loss from the main heater
T_2+T_1 is roughly $2T_2$, so that the average temperature of the heater is roughly the heater exit temperature T_2

The combination of equations (1) and (2) gives

$$mv_1 k_1 + mv_2 k_2 + mv_3 k_3 + mv_4 k_4 - \frac{U\,A}{B}(T_2 - T_a) = \frac{V \times I}{4.187\, B} \qquad (3)$$

where the factor B is $\pi r^2 \rho\, C_p\, (T_2 - T_1)$.

The variables in equation (3) include

knowns: ρ, r, C_p
to be measured: mv_i, V, I, T_1, T_2, T_a
unknown and to be determined: k_i, $(UA)^2$

Thermal balance procedure

1. Bring loop to steady state.

   a. $T_{max} = T_2 = 320$ C (Typical).
   b. T_{diff} between maximum and minimum loop temperatures should be about 100 degrees C.
   c. Total lithium flowrate through loop about .02 kg s^{-1} (5×10^{-5} m^3 s^{-1}).
   d. All electrical power to main heater is controlled by variable transformers, as the automatic controller output is more difficult to measure. (Unless automatic controller load is receiving essentially constant power.) The temperature rise of the lithium going through the main heater, $(T_2 - T_1)$, is about 10 degrees C.

2. Connect flowmeters to millivolt recorder channels 1 to 4.

3. Select thermocouples to monitor on the millivolt recorder channels 5 to 16.

   a. Select three thermocouples (denote as x, y, and z) on pump piping section (but not near pump cell) upstream of the main heater. These will be averaged to give the lithium inlet temperature, T_1.
   b. Select three thermocouples (denote as X, Y, and Z) on the lower lithium manifold (not on the heater outlet end) to give the lithium temperature T_2 at the heater exit.
   c. Connect one of the thermocouple extension wires (between the thermocouple junction box and the recorders) in series and opposed to 10 millivolts output by a potentiometer. This will bring the output of the chromel-alumel thermocouples down to the 0 - 10 millivolt range of the millivolt recorder, which is more sensitive than the thermocouples recorders. Connect this modified thermocouple extension wire to channels 5 - 16 of the millivolt recorder.

   It would be wise to check all recorders at several points with the potentiometer, to ensure proper calibration.

4. Take data for thermal calibration tests.

   a. On recorder C, record the main heater temperatures (12 thermocouples from vicinity of main heater, but not including x,y,z,X,Y, or Z).
   b. Measure the main heater voltage and current (these values may be different for the different clamshells. If so, the power to each clamshell should be calculated and the total power should be used in place of the V x I product in equation (3).
   c. Record the four flowmeter signals and the 10-millivolt offset signal from thermocouple x. Let the recording continue for at least one cycle of the recorder. Use channels 1 - 4 for the meters and 5 - 16 for the thermocouple.
   d. Repeat step 4.c. using thermocouple X,Y,y,z,Z,X,x,y,Y, Z,z. This will give replicated measurements of three pairs of temperature differences (e.g., X-x,Y-y,Z-z) corresponding to the lithium temperature rise in the heater. Each temperature difference will have been calculated determining exit temperature before inlet temperature, then vice-versa, to minimize the effect of a slow rise or fall in the loop temperature, which is possible if the automatic temperature control is not in effect.
   5. On recorder C, log the temperatures in the vicinity of the main heater. They should still be within a few degrees of the values found in step 4.a., or the loop is not really at steady state and the calibration results will not be reliable. Also recheck the power to the main heater. It should not have changed since step 4.b.

5. Vary the flow rates.

   _. Adjust the flow control valves to different settings. Repeat part 4. Eight or more tests should be made at some of the 2^4 combinations (16 combinations) of each valve being open or shut.(approximately). The practical valve combinations are limited somewhat since for convenience and in order to keep the loop at steady state the total flow rate must be approximately constant. Before taking data for any test be sure that the loop is at steady state. It may be necessary to adjust the heater power slightly to correct for different total flow rates.

6. Change the loop maximum temperature (that is, the heater temperature) to help determine the heat transfer coefficient U A (actually the product of the heat transfer coefficient, and the heater area; heat transfer is assumed to be by conduction rather than radiation or a combination of the two.) A maximum temperature of 400 C is reasonable for the second test. Repeat parts 4 and 5.

7. Fit equation (3) to the data by least squares, to determine the k_i's and product UxA (needed by calculations although not necessarily needed for operating the loop.)

   See the METERS program (following pages).

Mass balance procedure (drain test)

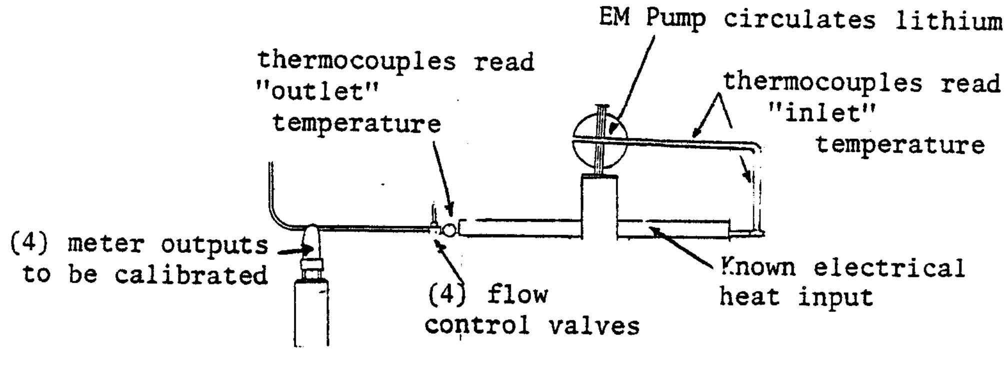
Equation (1) still applies. In this case lithium is not being pumped through the loop,but rather drains from the surge tank to the dump tank through one or more test sections (meter sections). In this case the total flow rate through all meter sections is

$$\dot{m} = \frac{\pi R^2 \rho}{t}(h_1 - h_2) \qquad (4)$$

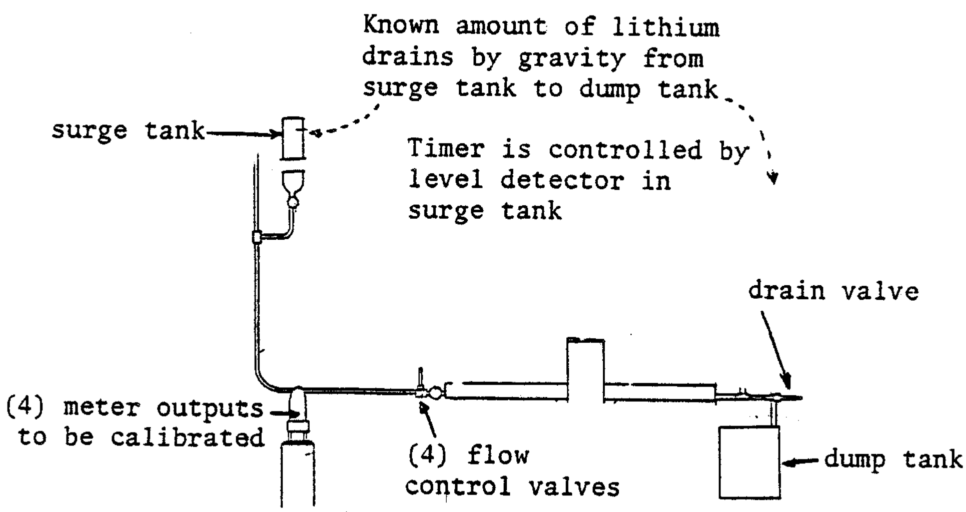
where: R is the surge tank inside diameter
h_1 is the initial height of lithium in surge tank
h_2 is the final height of lithium in surge tank
t is the time needed to drain the lithium from level h_1 to level h_2

Combination of equations (1) and (4) gives

$$\dot{m}v_1 k_1 + \dot{m}v_2 k_2 + \dot{m}v_3 k_3 + \dot{m}v_4 k_4 = \frac{R^2}{r^2}\frac{(h_1 - h_2)}{t} \qquad (5)$$



ENERGY BALANCE METER CALIBRATION SCHEME



MASS BALANCE METER CALIBRATION SCHEME

Data collection for drain tests.

1. Bring loop to standby conditions. See Procedures for stringer service, part I.

2. Flowmeter connections to millivolt recorder must be reversed, since during drain tests, lithium flows in opposite direction than during normal pumped flow operation.

3. Connect flowmeter #1 output to odd channels of millivolt recorder. Connect flowmeter #2 output to even channels of the recorder. Close valves I,3, and 4 as far as possible. Open valve 2 as far as possible. Turn on the flowmeter recorder.

4. Drain lithium from surge tank to dump tank following the procedure in part II.C. of the stringer servicing operations, except that the freeze standpipes are in this case still frozen and the ball valves and gas valves associated with them should be closed. Record the time taken for a known volume of lithium to flow from the surge tank to the dump tank. (Start timing at selected lithium level on continuous indicator, or when the upper short-out level probe breaks contact with the lithium. Stop timing at a selected lower lithium level or when the lower short-out probe breaks contact with the lithium. Do not empty the surge tank completely or argon may get into the economizer.) Use level probe microswitches to start and stop timer. Drain about 6 inches of lithium from the surge tank. This should take about 30-40 seconds. One or two trials should be sufficient to determine how far open the dump valve must be to give this kind of flow rate.

5. Refill the lithium into the surge tank using procedure VIII of the stringer service operations. It is not necessary to vacuum and backfill the tanks until the drain tests are over. However, if the testing is halted for very long, vacuum and backfill the surge and dump tanks before leaving the loop.

6. Repeat steps 4 and 5 two or three times. This will allow the determination of the calibration factor for meter #2.

7. Repeat steps 3,4,5,and 6 with meters 1,3, and 4 substituted for meter 2 (valves 1, 3, and 4 substituted for valve 2). This will allow calibration of meters 1, 3, and 4.

8. Use equation (5) and least squares to determine the meter calibration factors k_i. See program METERS (following pages).

Least squares meter calibration program, METERS.

For each calibration run, recorded millivoltages are averaged using in all cases at least 4 or 5 recorder points. The averaged values are input to the program. There may be an offset in any or all of the millivolt recorder channels; if an offset exists on channels 1-4 (meter records for thermal tests) or in any channels for the drain tests, modify the program to correct for the offset, or correct the values by hand before input.

The input standard deviation is not important unless both drain and thermal tests are combined in the least squares analysis. In this case, the standard deviation should reflect the relative uncertainty in each procedure. One way to estimate this uncertainty is to carry out the calibration separately with each kind of test, and find the standard error of the flow rates predicted with the resulting calibration factors. This standard error may be used as an approximate standard deviation to indicate the relative uncertainly to the different types of data. Generally the drain tests appear to be more precise. One calibration session indicated that a drain test should be given four times as much weight as a thermal test.

When only drain or only thermal tests are used, the input standard deviation should be unity.

Experience has shown that the flowmeter recorder zero may drift. The flowmeter output voltage should be checked with a regular manual potentiometer at monthly intervals with the pump set at the same power setting, for instance,10%. Tightening the connections of the wound resistor located on the card above the meter-lead terminals (next to the constant voltage unit inside the flowmeter recorder) may restore the zero. Check the recorder vacuum tubes if trouble persists.

Before using the flowmeter (millivolt) recorder for calibration data, check the performance by running through several recorder cycles with all the channels connected to a manual potentiometer supplying various voltages between 0 and 10 millivolts.

```
C       LATEST REVISION APRIL 28, 1980
        PROGRAM METERS(DATAM,TAPE5=DATAM,OUTMTR,TAPE6=OUTMTR,PRINT)
C ***WRITTEN BY DON BAUER AT UNIV OF WISC SEPT 1978
C ***FIRST ON ECL...WRITTEN IN LIVERMORE FILES MAY 18,1979
C ***PROGRAM TO CALIBRATE MAGNETIC FLOWMETERS OF LITHIUM LOOP
        CALL CHANGE (4R+MTR)
        DIMENSION S(30,25),DIFF(30,7),X(30,6),A(10,20)
C***     NUMBER OF TRIALS IS NOB
        READ(5,7)NOB
        DO 10 I=1,NOB
 5      FORMAT(8F10.3)
 6      FORMAT(6F10.2)
 7      FORMAT(2I2,6X,F10.4)
C***READ IN MV1,MV2,MV3,MV4, TF,V,I,K
C*** MV ARE MILLIVOLTS FROM METER CHANNELS
C*** TF IS HEATER TEMPERATURE IN DEGREES FAHRENHEIT(0 FOR DRAIN TEST)
C*** V AND I ARE VOLTS AND TOTAL AMPERES TO MAIN HEATER
C***     OR , FOR DRAIN TEST, V IS TIME IN SECONDS
C***                   I IS LEVEL CHANGE IN INCHES(EXPANSION TANK)
C*** K IS FROM CHROMEL-ALUMEL TABLES, MV/20 DEGREES FAHRENHEIT
C***                                       AT HEATER TEMPERATURE.
        READ(5,5)(S(I,J),J=1,4),(S(I,J),J=17,20)
C***     SET DEFAULT STANDARD ERROR TO 1.
        S(I,21)=1.
C***READ 12 THERMOCOUPLE MILLIVOLTAGES: XXYYZZXXYYZZ, HIGH/LO,HI/LO...
 10     READ (5,6)(S(I,J),J=5,16)
C***READ ESTIMATED STANDARD ERROR FOR EACH GROUP OF TRIALS
C
C       IF ZERO SHIFTING TO BE DONE BY PROGRAM, S(1,1) IS NEGATIVE
        IZSHFT=0
        IF(S(1,1).LT.0)IZSHFT=1
        S(1,1)=ABS(S(1,1))
 11     READ(5,7)ISIG,JSIG,SIG
        DO 12 IJSIG=ISIG,JSIG
 12     S(IJSIG,21)=SIG
        IF(JSIG.LT.NOB)GO TO 11
        WRITE(6,13)
 13     FORMAT(" METER CALIBRATION..4 METERS, TF,V,I,K,SIGMA,12
       +THERMOCOUPLE MV'S")
        WRITE(6,14)(((S(I,J),J=1,4),(S(I,J),J=17,21),(S(I,J),J=5,16)),I=
       +1,NOB)
C***FIRST PASS USE ISIG =1, JSIG = NOB, SIG=1.
C*** AFTER THERMAL AND DRAIN TESTS BOTH CALCULATED,CAN BE COMBINED
C***     BY WEIGHTING DATA WITH THE STANDARD DEVIATION SHOWN IN OUTPUT
C***     FOR THE PREDICTIONS.EXAMPLE:14 THERMAL TESTS WITH SIGMA=1.3
C***     AND 10 DRAIN TESTS WITH SIGMA =.3 WOULD BE COMBINED WITH
C***            NOB=10+14=24
C***      ISIG=1 JSIG = 14 SIG = 1.3  FOR THERMAL DATA ,ENTERS FIRST
C***    ISIG=15 JSIG = 24 SIG = .3 FOR DRAIN DATA ,ENTERS SECOND
 14     FORMAT(1X,4F7.4,4X,5F8.3,/,6F10.3,/,6F10.3)
C***CALCULATE  MV TEMPERATURE DIFFERENCES 6 PAIRS AND ONE AVERAGE
        DO 15 I=1,NOB
        DIFF(I,7)=0.
        DO 15 J=1,6
        J5=2*(J-1)+5
        J6=2*(J-1)+6
        DIFF(I,J)=S(I,J5)-S(I,J6)
 15     DIFF(I,7)=DIFF(I,7)+DIFF(I,J)/6.
        WRITE(6,16)
 16     FORMAT(" THERMOCOUPLE DIFFERENCES IN MV..6 PAIRS, ONE AVERAGE")
```

```
      WRITE(6,17)((DIFF(I,J),J=1,7),I=1,NOB)
 17   FORMAT(1X,6F10.4,2X,F10.4)
      PI=3.14159
      HEATC=1.
      RADIU=.527*.5*2.54
      DO 20 I=1,NOB
      DENST=.515-.000101*((S(I,17)-32.)/1.8-200.)
C***DEFAULT FACTOR = 1.
      FACTOR=1.
      IF(S(I,17).LE.80.)GO TO 18
C***FOR THERMAL TESTS:
      FACTOR =PI*RADIU**2*(DENST*HEATC*5./9.*4.187)*
     +20./S(I,20)*DIFF(I,7)
C***CORRECT FOR METER RECORDER OFFSETS FROM TRUE ZERO
 18   IF(IZSHIFT.NE.1)GO TO 181
      X(I,1)=(S(I,1)-.02)/S(I,21)
      X(I,2)=(S(I,2)-.04)/S(I,21)
      X(I,3)=(S(I,3)-.01)/S(I,21)
      X(I,4)=(S(I,4)-.01)/S(I,21)
      GO TO 182
 181  X(I,1)=S(I,1)/S(I,21)
      X(I,2)=S(I,2)/S(I,21)
      X(I,3)=S(I,3)/S(I,21)
      X(I,4)=S(I,4)/S(I,21)
 182  X(I,5)=(S(I,17)-80.)/FACTOR/S(I,21)
C***FOR THERMAL TESTS: X6 = V*I/FACTOR/STD DEV
      IF(S(I,17).GT.80.)X(I,6)=S(I,18)*S(I,19)/FACTOR/S(I,21)
C***FOR DRAIN TESTS X6 =RADII RATIO SQUARED * LEVEL CHANGE/TIME/STD DEV
      IF(S(I,17).LE.80..AND.S(I,19).EQ.0)S(I,19)=5.3125
 20   IF(S(I,17).LE.80.)X(I,6)=8.083**2*S(I,19)*2.54/S(I,18)/S(I,21)
C***GENERATE XX MATRIX FOR LEAST SQUARES
      DO 40 I=1,5
      DO 40 J=1,6
      A(I,J)=0.
      DO 40 K=1,NOB
      A(I,J)=A(I,J)+X(K,I)*X(K,J)
 40   CONTINUE
C***GENERATE IDENTITY MATRIX TO RIGHT OF XX MATRIX(CONVERT TO INVERSE)
      WRITE(6,50)
      DO 45 J=7,11
      DO 45 I=1,5
      A(I,J)=0.
      IF(J.EQ.(I+6))A(I,J)=1.
 45   CONTINUE
 50   FORMAT(" MATRIX READY TO SOLVE, AUGMENTED AND WITH UNITY MATRIX")
      WRITE(6,55)((A(I,J),J=1,11),I=1,5)
 55   FORMAT(1X,4F7.4,E12.4,3X,6E12.4)
C***SOLVE AND INVERT XX MATRIX BY GAUSS-JORDAN ELIMINATION
      CALL PRISM(A,5,11)
      WRITE(6,60)
 60   FORMAT(" THE SOLUTION MATRIX AND INVERSE ARE:")
      WRITE(6,55)((A(I,J),J=1,11),I=1,5)
 65   FORMAT(" COMPARISON OF ACTUAL TO PREDICTED DEPENDENT VARIABLE")
      WRITE(6,65)
      VAR=0.
      DO 80 J=1,NOB
      SUM=0.
      DO 70 I=1,5
C***LINEAR PREDICTION OF DEPENDENT VALUE FROM INDEPENDENTS AND PARAMS
 70   SUM=SUM+X(J,I)*A(I,6)
```

```
      IF(S(J,17).LE.80.)GO TO 71
C***FOR THERMAL TESTS CALCULATE EXPERIMENTAL DEPENDENT VARIABLE
      DENST=.515-.000101*((S(I,17)-32.)/1.8-200.)
      FACTOR=PI*RADIU**2*(DENST*HEATC*5./9.*4.187)*
     +20./S(J,20)*DIFF(J,7)
C***FOR DRAIN TESTS CALCULATE EXPERIMENTAL DEPENDENT VARIABLE
      IF(S(J,17).GT.80.)EXP=S(J,18)*S(J,19)/S(J,21)/FACTOR
      IF(S(J,17).LE.80..AND.S(I,19).EQ.0)S(I,19)=5.3125
71    IF(S(J,17).LE.80.)EXP=(4.26/.527)**2*2.54*S(J,19)/S(J,18)
     +/S(J,21)
C ***CONTRIBUTION TO VARIANCE
      VAR=VAR+(EXP-SUM)**2
80    WRITE(6,90)J,EXP,SUM
      ANOB=NOB
      SIGMA=(VAR/(ANOB-5.))**.5
C***OR FOR DRAIN TESTS ONLY 4 DEGREES OF FREEDOM USED:
      IF(S(I,17).LE.80.)SIGMA=(VAR/(ANOB-4.))**.5
85    FORMAT(" STANDARD ERROR OF PREDICTIONS IS ",E12.4)
      WRITE(6,85)SIGMA
90    FORMAT(" DATA SET ",I2,"  EXPERIMENT= ",E12.5," PREDICT ="
     +,E12.5)
      DO 95 I=1,5
      IPLUS=I+6
      IPLUS=I+6
C***STANDARD DEV OF PARAMETER APPROX
C***   SIGMA * SQUARE ROOT OF CORRESPONDING DIAGONAL ENTRY OF INVERSE
      STDEV=SIGMA*A(I,IPLUS)**.5
95    WRITE(6,96)I,A(I,6),STDEV
96    FORMAT(" PARAMETER # ",I2," IS ",E12.4," , EST STD DEV = "
     +,E12.4)
      CALL QUIT(1)
      END
C
C
C
      SUBROUTINE PRISM(A,N,M)
C     PROGRAM REDUCE INVERT SOLVE MATRIX
      DIMENSION A(10,20)
C     WRITTEN BY DONALD BAUER AT ^MUSKEGON ^COMMUNITY ^COLLEGE
C     CALCULUS/COMPUTER CLASS  APPROX 1971
C     WRITTEN INTO MY LIVERMORE FILES ^MAY 11, 1979
C     MINRO IS LESSER OF NUMBER OF COLUMNS OR ROWS
C     USE EACH ROW TO REDUCE OTHER ROWS
C     GET ONLY ONE NON-ZERO ENTRY IN COLUMNS 1 TO N.(N=NO. OF ROWS)
      MINRO=(N+M-IABS(N-M))/2
      DO 5 J=1,MINRO
      DO 3 I=1,N
      IF(ABS(A(I,J)).LE.0.)GO TO 3
35    FACTR=1./A(I,J)
      DO 36 K=1,M
      A(I,K)=A(I,K)*FACTR
36    CONTINUE
3     CONTINUE
      DO 5 L=1,N
      IF(L.EQ.J)GO TO 5
4     IF(ABS(A(L,J)).LE.0.)GO TO 5
C     SUBTRACT ROW J FROM ROW L
44    DO 45 I1=1,M
45    A(L,I1)=A(L,I1)-A(J,I1)
5     CONTINUE
```

```
C      MAKE THE DIAGONAL ENTRIES ALL UNITY
       DO 8 I=1,MINRO
       IF(ABS(A(I,I)).GT.0.)GO TO 6
55     WRITE(6,200)I,I
200    FORMAT(/," DIAGONAL ENTRY (",I2,",",I2,") IS ZERO ",/,
     + "REDUCTION STOPS, CONTROL RETURNED TO CALLING PROGRAM.")
       GO TO 9
6      FACTR=1./A(I,I)
       DO 7 J=1,M
7      A(I,J)=A(I,J)*FACTR
8      CONTINUE
9      RETURN
       END
```

24							
	.68	.00	.00	.00	80.00	59.0	5.74
0.							
0.							
	.79	.00	.00	.00	80.00	52.5	5.74
0.							
0.							
	.77	.00	.00	.00	80.00	54.5	5.74
0.							
0.							
	.62	.00	.00	.00	80.00	68.0	5.74
0.							
0.							
	.65	.00	.00	.00	80.00	61.0	5.74
0.							
0.							
	.22	.00	.37	.00	80.00	62.0	5.74
0.							
0.							
	.33	.00	.52	.00	80.00	46.5	5.74
0.							
0.							
	.23	.00	.45	.00	80.00	53.0	5.74
0.							
0.							
	.30	.00	.52	.00	80.00	45.8	5.74
0.							
0.							
	.29	.00	.54	.00	80.00	44.6	5.74
0.							
0.							
	.35	.00	.66	.00	80.00	36.8	5.74
0.							
0.							
	.32	.00	.00	.67	80.00	39.0	5.74
0.							
0.							
	.31	.00	.00	.70	80.00	38.6	5.74
0.							
0.							
	.31	.00	.00	.48	80.00	48.7	5.74
0.							
0.							
	.29	.00	.00	.47	80.00	44.8	5.74
0.							
0.							
	.17	.64	.00	.00	80.00	48.0	5.74
0.							
0.							
	.20	.68	.00	.00	80.00	45.0	5.74
0.							
0.							
	.27	.84	.00	.00	80.00	36.8	5.74
0.							
0.							
	.19	.65	.00	.00	80.00	46.8	5.74
0.							
0.							
	.21	.65	.00	.00	80.00	44.0	5.74
0.							

Supplementary listing of drain calibration data--second set of 24 tests; followed by first set of 10 tests.

61	0.							
62		.92	.00	.00	.00	80.00	42.8	5.74
63	0.							
64	0.							
65		.97	.00	.00	.00	80.00	45.0	5.74
66	0.							
67	0.							
68		.85	.00	.00	.00	80.00	46.0	5.74
69	0.							
70	0.							
71		.77	.00	.00	.00	80.00	50.0	5.74
72	0.							
73	0.							
74	0124		1.					
75	10							
76		-.950	.040	.010	.010	80.000	42.250	
77		.00	.00	.00	.00	.00	.00	
78		.00	.00	.00	.00	.00	.00	
79		.934	.040	.010	.010	80.000	44.300	
80		.00	.00	.00	.00	.00	.00	
81		.00	.00	.00	.00	.00	.00	
82		.995	.040	.010	.010	80.000	40.830	
83		.00	.00	.00	.00	.00	.00	
84		.00	.00	.00	.00	.00	.00	
85		.427	.777	.010	.010	80.000	36.500	
86		.00	.00	.00	.00	.00	.00	
87		.00	.00	.00	.00	.00	.00	
88		.480	.817	.010	.010	80.000	32.800	
89		.00	.00	.00	.00	.00	.00	
90		.00	.00	.00	.00	.00	.00	
91		.453	.040	.628	.010	80.000	36.220	
92		.00	.00	.00	.00	.00	.00	
93		.00	.00	.00	.00	.00	.00	
94		.523	.040	.727	.010	80.000	31.54	
95		.00	.00	.00	.00	.00	.00	
96		.00	.00	.00	.00	.00	.00	
97		.493	.040	.010	.743	80.000	34.25	
98		.00	.00	.00	.00	.00	.00	
99		.00	.00	.00	.00	.00	.00	
100		.573	.040	.010	.838	80.000	29.47	
101		.00	.00	.00	.00	.00	.00	
102		.00	.00	.00	.00	.00	.00	
103		.647	.040	.010	.993	80.000	25.930	
104		.00	.00	.00	.00	.00	.00	
105		.00	.00	.00	.00	.00	.00	
106	0110		1.					
107								

Supplementary listing of drain calibration data--
second set of 24 tests (continued from last page)
and first set of 10 tests.

```
COMPARISON OF ACTUAL TO PREDICTED DEPENDENT VARIABLE
DATA SET  1  EXPERIMENT=  5.56380E+01 PREDICT = 5.49993E+01
DATA SET  2  EXPERIMENT=  5.23201E+01 PREDICT = 5.25938E+01
DATA SET  3  EXPERIMENT=  5.20812E+01 PREDICT = 5.23746E+01
DATA SET  4  EXPERIMENT=  4.82274E+01 PREDICT = 4.77747E+01
DATA SET  5  EXPERIMENT=  5.41842E+01 PREDICT = 5.50150E+01
DATA SET  6  EXPERIMENT=  5.10326E+01 PREDICT = 5.09820E+01
DATA SET  7  EXPERIMENT=  5.05800E+01 PREDICT = 5.02416E+01
DATA SET  8  EXPERIMENT=  5.69258E+01 PREDICT = 5.71719E+01
DATA SET  9  EXPERIMENT=  5.18178E+01 PREDICT = 5.32923E+01
DATA SET 10  EXPERIMENT=  6.58341E+01 PREDICT = 6.52452E+01
DATA SET 11  EXPERIMENT=  4.75252E+01 PREDICT = 4.57969E+01
DATA SET 12  EXPERIMENT=  4.66963E+01 PREDICT = 4.49534E+01
DATA SET 13  EXPERIMENT=  4.83381E+01 PREDICT = 4.64466E+01
DATA SET 14  EXPERIMENT=  1.58537E+02 PREDICT = 1.54122E+02
STANDARD ERROR OF PREDICTIONS IS   1.9222E+00
PARAMETER #  1 IS   1.4451E+01 , EST STD DEV =   1.4699E+00
PARAMETER #  2 IS   1.7069E+01 , EST STD DEV =   1.7646E+00
PARAMETER #  3 IS   1.9459E+01 , EST STD DEV =   1.8675E+00
PARAMETER #  4 IS   1.9239E+01 , EST STD DEV =   2.1162E+00
PARAMETER #  5 IS   1.6203E+00 , EST STD DEV =   2.8920E-02
```

THERMAL TESTS (14)

```
COMPARISON OF ACTUAL TO PREDICTED DEPENDENT VARIABLE
DATA SET  1  EXPERIMENT=  2.08691E+01 PREDICT = 2.06006E+01
DATA SET  2  EXPERIMENT=  1.99034E+01 PREDICT = 2.02742E+01

DATA SET  3  EXPERIMENT=  2.15949E+01 PREDICT = 2.15186E+01
DATA SET  4  EXPERIMENT=  2.41567E+01 PREDICT = 2.45876E+01
DATA SET  5  EXPERIMENT=  2.68817E+01 PREDICT = 2.64643E+01
DATA SET  6  EXPERIMENT=  2.43435E+01 PREDICT = 2.43206E+01
DATA SET  7  EXPERIMENT=  2.79556E+01 PREDICT = 2.79687E+01
DATA SET  8  EXPERIMENT=  2.57436E+01 PREDICT = 2.59865E+01
DATA SET  9  EXPERIMENT=  2.99192E+01 PREDICT = 2.95249E+01
DATA SET 10  EXPERIMENT=  3.40039E+01 PREDICT = 3.41448E+01
STANDARD ERROR OF PREDICTIONS IS   3.6752E-01
PARAMETER #  1 IS   2.0400E+01 , EST STD DEV =   2.2906E-01
PARAMETER #  2 IS   1.9887E+01 , EST STD DEV =   3.5728E-01
PARAMETER #  3 IS   2.2425E+01 , EST STD DEV =   4.1588E-01
PARAMETER #  4 IS   2.0067E+01 , EST STD DEV =   2.8665E-01
PARAMETER #  5 IS   0.           , EST STD DEV =   3.6752E-01
```

FIRST SET — DRAIN TESTS (10)

```
METER CALIBRATIONS--FIRST SET OF DRAIN TESTS
Multiply program output calibration factors
  time the ratio of meter tubing to test coupon
  inside areas (0.527/0.2425)**2=4.7) to
  get factor in cm/s(test section coupon zone)
  per millivolt output of meter.
  Meter#1  20.4 x 4.7 = 96 cm/s/mv
        2  19.9 x 4.7 = 94
        3  22.4 x 4.7 =105
        4  20.1 x 4.7 = 94
Calibration tests in September 1978.
```

```
COMPARISON OF ACTUAL TO PREDICTED DEPENDENT VARIABLE
DATA SET  1  EXPERIMENT=  1.61470E+01 PREDICT = 1.62101E+01
DATA SET  2  EXPERIMENT=  1.81461E+01 PREDICT = 1.88323E+01
DATA SET  3  EXPERIMENT=  1.74802E+01 PREDICT = 1.83555E+01
DATA SET  4  EXPERIMENT=  1.40099E+01 PREDICT = 1.47798E+01
DATA SET  5  EXPERIMENT=  1.56176E+01 PREDICT = 1.54949E+01   SECOND
DATA SET  6  EXPERIMENT=  1.53657E+01 PREDICT = 1.50043E+01   SET OF
                                                              DRAIN
DATA SET  7  EXPERIMENT=  2.04876E+01 PREDICT = 2.15832E+01   TESTS
DATA SET  8  EXPERIMENT=  1.79750E+01 PREDICT = 1.73529E+01   (24)
DATA SET  9  EXPERIMENT=  2.08007E+01 PREDICT = 2.08680E+01
DATA SET 10  EXPERIMENT=  2.13604E+01 PREDICT = 2.11572E+01
DATA SET 11  EXPERIMENT=  2.58878E+01 PREDICT = 2.57528E+01
DATA SET 12  EXPERIMENT=  2.44275E+01 PREDICT = 2.49497E+01
DATA SET 13  EXPERIMENT=  2.46806E+01 PREDICT = 2.54869E+01
DATA SET 14  EXPERIMENT=  1.95621E+01 PREDICT = 1.97992E+01
DATA SET 15  EXPERIMENT=  2.12650E+01 PREDICT = 1.90639E+01
DATA SET 16  EXPERIMENT=  1.98473E+01 PREDICT = 1.95598E+01
DATA SET 17  EXPERIMENT=  2.11705E+01 PREDICT = 2.12441E+01
DATA SET 18  EXPERIMENT=  2.58878E+01 PREDICT = 2.67896E+01
DATA SET 19  EXPERIMENT=  2.03562E+01 PREDICT = 2.02788E+01
DATA SET 20  EXPERIMENT=  2.16516E+01 PREDICT = 2.07556E+01
DATA SET 21  EXPERIMENT=  2.22587E+01 PREDICT = 2.19313E+01
DATA SET 22  EXPERIMENT=  2.11705E+01 PREDICT = 2.07393E+01
DATA SET 23  EXPERIMENT=  2.07103E+01 PREDICT = 2.02626E+01
DATA SET 24  EXPERIMENT=  1.90534E+01 PREDICT = 1.83555E+01
STANDARD ERROR OF PREDICTIONS IS   7.7926E-01
PARAMETER #  1 IS   2.3838E+01 , EST STD DEV =   3.3478E-01
PARAMETER #  2 IS   2.4230E+01 , EST STD DEV =   5.1077E-01
PARAMETER #  3 IS   2.6378E+01 , EST STD DEV =   6.4260E-01
PARAMETER #  4 IS   2.5853E+01 , EST STD DEV =   6.8307E-01
PARAMETER #  5 IS   0.         , EST STD DEV =   7.7926E-01
```

METER CALIBRATIONS--SECOND SET OF DRAIN TESTS

Multiply program output calibration factors times the ratio of meter tubing to test coupon inside areas (0.527/0.2425)**2 =4.7) to get factor in cm/s(test section coupon zone) per millivolt output of meter.

Meter #1	23.8 x 4.7 =	112 cm/s/mv
2	24.2 x 4.7 =	114
3	26.4 x 4.7 =	124
4	25.9 x 4.7 =	122

Calibration tests in April 1980.

APPENDIX P. PROGRAM LOSS

Estimated Pressure Drop Around Loop

Estimated Thermocouple Errors

(Uses subroutines FCN, DIA, TE
found in Appendix U: Program LPOPT)

PROGRAM COEFF

Examine effect on apparent mass transfer
coefficient of a chemical resistance
at the fluid-solid interface.
The results are only approximate,
and apply to first order interfacial
step.

```
      PROGRAM LOSS(RKDATA,TAPE5 = RKDATA,OUTLOS,TAPE6 = OUTLOS,PRINT)
C     LATEST REVISION APRIL 28,1980
C     PROGRAM TO CALCULATE APPROXIMATE PRESSURE DROP
C     AND THERMOCOUPLE ERRORS IN LITHIUM.
C     WRITTEN BY DONALD BAUER, UNIVERSITY OF WISCONSIN MADISON
C        CHEM ENGRG/NUCL ENGRG DEPARTMENT
C     OCTOBER 1979
C     PRESSURE CALCULATED WITH BLAUSIUS EQUATION FOR TURBULENT FLOW.
C     THERMOCOUPLE ERRORS  CALCULATED THIS WAY:
C     1. FIND HEAT LOSS TO SURROUNDINGS BY MEASURING ENERGY TO TRACE HEAT
C        AT STANDBY CONDITIONS WITH NO LITHIUM FLOW. (ELECTRICAL ENERGY)
C           ELECTRIC TRACE HEAT = VOLTS X AMPERES, OR I**2 R , ETC.
C     2. DETERMINE LOCAL CONDUCTANCE (U) FOR HEAT TRANSFER THROUGH
C        INSULATION BY EQUATION:
C        ELECTRIC TRACE HEAT/4.187 = 3.14*DIAMETER*U*(TEMP,STDBY-ROOMTEMP)
C     3. DETERMINE LOCAL HEAT LOSS DURING LITHIUM FLOW:
C        RUNNING LOSS = 3.14*DIAMETER*U*(TEMP,RUNNING-ROOMTEMP)
C     4. DETERMINE LOSS THROUGH PIPE FROM LITHIUM:
C        LOSS,LITHIUM = RUNNING LOSS - ELECTRIC TRACE HEAT/4.187
C     5. DETERMINE TEMPERATURE (ERRSS) THROUGH STEEL WALL BY:
C        LOSS, LITHIUM = 3.14*DIAMETER*CONDUCTIVITY,SS/WALLTHICK*ERRSS
C     6. DETERMINE TEMPERATURE DIFFERENCE (ERRLI) THROUGH LI BOUNDARY LAYER:
C        ERRLI = ERRSS * RESIST,LI/RESIST,SS
C           WHERE RESIST,SS = WALLTHICK/CONDUCTIVITY,SS
C           AND RESIST,LI   = 1/H(FILM HEAT TRANSFER COEFFICIENT)
C           WITH H CALCULATED FROM THE MARTINELLI EQUATION
C           AVERAGE BETWEEN CONSTANT HEAT FLUX AND CONSTANT WALL TEMPERATURE
C
C     7. IF THE COMPONENT IS AN ACTIVE HEAT TRANSFER UNIT, SUCH AS
C        THE MAIN HEATER, ECONOMIZER INNER PIPE, RADIATOR, OR UNIT WHERE THE
C        INSULATION LOSSES, IF ANY, ARE HARD TO DETERMINE, THE LOSS FROM THE
C        LITHIUM  IS CALCULATED AS:
C        LOSS,LITHIUM = 3.14/4*DIAMETER**2 * VELOCITY
C           *(DENSITY*HEATCAPACITY*TEMPERATURECHANGE)LITHIUM
C*****CALCULATIONS MADE ON BASIS OF ONE METER LENGTH OF PIPE.
C      NOTE THAT CONDUCTIVITY OF STAINLESS IS 113 BTU/HR/FT**2/(DEG F/INCH)
C      AND CONDUCTIVITY OF KAOWOOL INSULATION IS ABOUT .5 IN SAME UNITS
C      THICKNESS OF PIPE WALL IS ABOUT .1INCH
C      THICKNESS OF INSULATION IS ABOUT 2 INCHES
C      RESISTANCE TO HEAT TRANSFER THROUGH INSULATION IS THEREFORE
C      ABOUT 4000 TIMES AS GREAT AS RESISTANCE OF PIPE WALL.
C      THE TEMPERATURE DIFFERENCE BETWEEN THE LITHIUM AND THE ROOM TEMPERATURE
C      IS ALMOST ENTIRELY THROUGH THE INSULATION.
C
C.001       .0001     .00001                    50.020202000100040428102121000
C      SET UP DROPFILE FOR DEBUGGING; SET UP GRAPHICS ROUTINES.
       CALL CHANGE(4R+LOS)
       CALL KEEP80(1,3)
       CALL FR80ID("EXAMPLE",1,3)
       CALL PLTS
       DIMENSION ITPAK(60),TBULK(30),TREAD(30),TINWLL(30),XDRAW(30)
       DIMENSION DSCRPT(100)
C
       INTEGER DOPT,TOPT
       DIMENSION AREAD(20),A(20,5),A0(20,5)
       COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
      +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
      +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
      +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
      +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
```

```
          +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
          +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
          +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
          +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
          +,ZEXTRA(5),ABCD
           DIMENSION PDXO(20),PDX(20),SQPAR(2,20),PMOVE(20),Y(5),YPRIME(5)
          +,S(5)
           DATA N/2/,Y/5*1./,P/1./
           DATA A/623.,100.,2255.,1.6,2957.,1.,47.5,-18.,14500.,0.,100.,
          +9*0.,669.5,53.5,2255.,1.6,2957.,1.,47.5,-18.,14500.,0.,100.,
          +9*0.,669.5,53.5,2255.,1.6,2957.,1.,47.5,-18.,14500.,0.,100.,
          +9*0.,723.,80.5,0.,2.2,1500.,1.,58.,-18.,14500.,0.,50.,9*0.,
          +773.,100.,0.,2.2,232.,1.,4.23,-18.,14500.,1.27,8.,9*0./
           DATA FSPLIT/.398,.19,.131,.281,1.,
          +.398,.19,.131,.281,1.,15*1./,XTEST/20*350.,
          +10*275.,20*104./
C          ************************************************************
C          ************************************************************
C          READ IN SAME INFORMATION AS FOR METAL PROGRAM:
C          READ THESE VARIABLES AND PARAMETERS:
C          YI=INIT CONC            AINC=TRIAL STEP  EPSLIM=MASS BALANCE ACCURACY
C          X,Z=DUMMY VARIABLE                DPAR=FLAG: LE ZERO READ PARAMETER TRIAL STEPS
C                                           DPAR EQ ZERO READ PARAMETER VALUES
C          TOPT=TEMP FLAG: 1=SINE,2=TABLE    DOPT=DIAM FLAG: 1=CONSTANT,2=TABLE
C          LAMTUR=FLAG: POSITIVE=CONSTANT L/D, NEGATIVE=L/D CALCULATED EACH POINT
C          NIKIRN=FLAG: 0=IRON.
C          LNUM=LOOP NUMBER: #1:450/250; #2:500/300; #3:450/350; #4:ARD
C          IWT=WRITE FLAG
C          N1=FIRST LOOP CONSIDERED     N2=LAST LOOP CONSIDERED
C          IEXP=NEGATIVE POWER OF TEN CONVERGENCE
C          ITLIM NUMBER OF ITERATIONS ALLOWED ON PARAMETERS
C          ICUTL  CUTOFF (HIGH END OF LAMINAR RANGE)
C          ICUTH  CUTOFF (LOW END OF TURBULENT RANGE REYNOLDS NUMBER)
C          IHAUSN 0=SIEDER TATE  1=HAUSEN 2=MODIFIED S-T TRANSITION RANGE
C          ************************************************************
C          ************************************************************
C
C

           READ(5,300)YI(1,1),AINC(1,1),EPSLIM,DTIME,ETIME,DPAR,TOPT,DOPT,
          +LAMTUR,NIKIRN,LNUM,IWT,N1,N2,IEXP,ITLIM,ICUTL,ICUTH,IHAUSN,IFLXX
           DO 30 LNUM=N1,N2
           ZSTEP=100.
           ZETSTP=100.
  300      FORMAT(3F10.0,2F5.0,F10.0,20I2)
           WRITE(6,1)
           WRITE(6,2)
           WRITE(6,3)
    1      FORMAT(//////////," PRESSURE DROP AND THERMOCOUPLE CORRECTION FOR
          + LITHIUM LOOP",//," LOOP COMPONENTS ARE INDEXED AS:",/,
          +" IX=0-2:HEATER    IX=3:METERS    IX=4:TEST ZONE",
          +/," IX=4-11:ECON     IX=11-18:RADIATOR",
          */," IX=19:COLD END  IX=20-27:ECON  IX=27-30:PUMPING",
          +/," FOR TEST ZONE IX=4, ERROR IS CALCULATED FOR A ")
    2      FORMAT("  1 DEG CENTIGRADE TEMP DROP FOR LITHIUM STREAM PER METER
          +",/," WITH LITHIUM AT APPROXIMATELY 100CM/S FLOW VELOCITY",
          +/,"  TEMPERATURE DROP SHOWN FOR ACROSS PIPE WALL AND ",/,
          + "  FOR ACROSS LITHIUM BOUNDARY LAYER.",/,
          +"  VALUES SHOWN ARE FOR INDEX, DIAMETER AND WALL THICKNESS(CM)",
          +/,"  TEMPERATURE:STANDBY(APPROX.) & WHILE RUNNING(LINEARIZED)(C)",
          +/,"  ELECTRICAL TRACE HEAT LOSS IN CAL/SEC/(CM OF PIPE)",
```

```
     +/,"     AND LITHIUM HEAT LOSS (THROUGH WALL) CAL/SEC/CM",
     +/," AND TEMPERATURE DROPS ACROSS STAINLESS AND BOUNDARY LAYER.(C)"
     +/)
 3    FORMAT(" X    D     W     PSI  TSTNBY TEMP QLOSS0 QLOSSR ERR,SS
     + ERR,LI")
 C
 C    CALCULATE LOGARITHMIC CONSTANTS TO BE USED LATER
      CUTL=100.*ICUTL
      CUTH=100.*ICUTH
      CUTLL=ALOG(CUTL)
      CUTHL=ALOG(CUTH)
 C***********************NOTE  USE OF 1.62, LEVEQUE, RATHER THAN S-T 1.86**********
 C    **********************NOTE TURBULENT RANGE USE OF .026 COEFFICIENT***********
      ALN186=ALOG(1.62)
      ALN26=ALOG(.026)
      BPOWER=ALOG(3300.)-ALOG(2100.)
      REALK=EXP(ALOG(2100.)/BPOWER)
 C
 C    ESTIMATED TEMPERATURE OF ROOM CLOSE TO ENCLOSURE 50C
      TINF=50.
 C    RELATIVE PRESSURE
      PRESSR=0.
      DO 10 IX=1,30
 C    STEP THROUGH LOOP
      X=(IX-1)*100.+.1
      ISECT=5
      IF(X.GE.200..AND.X.LE.400)ISECT=4
      CALL FCN(Y,X,N,YPRIME)
 C    DPDX * 100CM=PRESSURE CHANGE THIS STEP
      PRESSR=PRESSR+DPDX*100.
      PSI=PRESSR*2.54**2*2.248E-6
      DIAOUT=DIAM+2.*WTHICK
      TIN=T
 C
 C    CHANGE WATTS PER CM TO CALORIES PER CM
      PI=3.14159
      QLOSS0=QLOSS0/4.187
      IF(QLOSS0.EQ.0.0)GO TO 5
 C    QLOSSR=APPROXIMATE HEAT LOSS AT OPERATING TEMPERATURE
      UCOEFF=QLOSS0/(PI*DIAOUT*(TSTNBY-TINF))
      QLOSSR=UCOEFF*PI*DIAOUT*(TC-TINF)-QLOSS0
      GO TO 6
 C
 C
 C    DETERMINE HEAT LOSS BY ENERGY BALANCE ON LITHIUM STREAM
 5    X=X+99.9
      CALL FCN(Y,X,N,YPRIME)
      HEATCP=1.
      TCHANG=(TIN-T)/100.
      IF(X.GE.300..AND.X.LE.400.)TCHANG=.01
 C    TEMP CHANGE PER CM AONG PIPE
      QLOSSR=PI*(DIAM**2-DIAA**2)/4.*VEL*DENS* HEATCP*TCHANG
 C
 C    CALCULATE ERROR IN DELTA TEMPERATURE ACROSS STAINLESS WALL
 6    ERRSS=-QLOSSR*DIAOUT*ALOG(DIAOUT/DIAM)/(THRMSS*PI*DIAOUT)
 C    CALCULATE INSIDE FILM HEAT TRANSFER COEFFICIENT:
 C       MARTINELLI EQUATION, AVERAGE OF CONSTANT FLUX/CONSTANT WALL TEMP
      HCOEFF=THRMLI/DMD*(6.+.025*(REYN*PRNDTL)**.8)
 C    CALCULATE ERROR IN DELTA TEMPERATURE ACROSS BOUNDARY LAYER
      ERRLI=ERRSS*(DIAOUT/DIAM/HCOEFF)/(DIAOUT*ALOG(DIAOUT/DIAM)
```

```
     +/THRMSS)
C
C
      XDRAW(IX)=IX
      TREAD(IX)=TC
      TINWLL(IX)=TC-ERRSS
      TBULK(IX)=TC-(ERRSS+ERRLI)
10    WRITE(6,20)IX,DIAM,WTHICK,PSI,TSTNBY,TC,QLOSS0,QLOSSR,ERRSS,ERRLI
20    FORMAT(I3,F6.2,F7.2,F7.2,F6.0,F6.0,F6.2,F7.2,F6.2,F6.2)
C
C
C     GRAPH THE TEMPERATURES
      CALL NOBRDR
      CALL GRACE(0.)
      CALL LINES('OUTSIDE WALL$',ITPAK,1)
      CALL LINES('INSIDE  WALL$',ITPAK,2)
      CALL LINES('BULK LITHIUM$',ITPAK,3)
      CALL LINES(' 0- 2M   HEATER$',DSCRPT,1)
      CALL LINES(' 2- 3M   METERS$',DSCRPT,2)
      CALL LINES(' 3- 4M  COUPONS$',DSCRPT,3)
      CALL LINES(' 4-11M ECONMIZR$',DSCRPT,4)
      CALL LINES('11-18M RADIATOR$',DSCRPT,5)
      CALL LINES('18-20M COLD END$',DSCRPT,6)
      CALL LINES('20-27M ECONMIZR$',DSCRPT,7)
      CALL LINES('27-30M  PUMPING$',DSCRPT,8)
      CALL LINES('TEMPERATURES$',DSCRPT,9)
      CALL LINES('ARE LINEARIZED$',DSCRPT,10)
      CALL COMPLX
      CALL TITLE('LITHIUM LOOP TEMPERATURES$',100,'POSITION,
     + METERS$',100,'DEGREES CENTIGRADE$',100,6.,8.)
      CALL GRAF(0.,5.,30.,250.,50.,500.)
      CALL DFRAME
      CALL CURVE(XDRAW,TREAD,30,1)
      CALL CURVE(XDRAW,TINWLL,30,1)
      CALL CURVE(XDRAW,TBULK,30,1)
      CALL LEGEND(ITPAK,3,2.5,6.75)
      CALL STORY(DSCRPT,10,2.5,4.5)
30    CALL ENDPL(0)
      CALL DONEPL
      CALL PLOTE
      CALL QUIT(1)
      END
C
C
C
C
C     ************************************************************
C     ************************************************************
C     ************************************************************
C     NEEDS SUBROUTINE FCN(Y,X,N,YPRIME) FROM PROGRAM METAL
C     NEEDS FUNCTION DIA(X) FROM PROGRAM METAL
C     *****************************************************************
C     NEEDS FUNCTION TE(X) FROM PROGRAM METAL
```

PRESSURE DROP AND THERMOCOUPLE CORRECTION FOR LITHIUM LOOP

LOOP COMPONENTS ARE INDEXED AS:
IX=0-2:HEATER IX=3:METERS IX=4:TEST ZONE
IX=4-11:ECON IX=11-18:RADIATOR
IX=19:COLD END IX=20-27:ECON IX=27-30:PUMPING
FOR TEST ZONE IX=4, ERROR IS CALCULATED FOR A
1 DEG CENTIGRADE TEMP DROP FOR LITHIUM STREAM PER METER
WITH LITHIUM AT APPROXIMATELY 100CM/S FLOW VELOCITY
TEMPERATURE DROP SHOWN FOR ACROSS PIPE WALL AND
FOR ACROSS LITHIUM BOUNDARY LAYER.
VALUES SHOWN ARE FOR INDEX, DIAMETER AND WALL THICKNESS(CM)
TEMPERATURE:STANDBY(APPROX.) & WHILE RUNNING(LINEARIZED)(C)
ELECTRICAL TRACE HEAT LOSS IN CAL/SEC/(CM OF PIPE)
AND LITHIUM HEAT LOSS (THROUGH WALL) CAL/SEC/CM
AND TEMPERATURE DROPS ACROSS STAINLESS AND BOUNDARY LAYER.(C)

X	D	W	PSI	TSTNBY	TEMP	QLOSS0	QLOSSR	ERR,SS	ERR,LI
1	6.00	0.60	-0.00	1.	435.	0.	-6.64	8.08	2.69
2	6.00	0.60	-0.00	1.	450.	0.	-7.11	8.66	2.87
3	1.35	0.12	-0.00	397.	450.	0.17	0.03	-0.03	-0.01
4	0.62	0.42	-0.08	397.	441.	0.	0.13	-0.77	-0.05
5	2.50	0.09	-0.08	1.	419.	0.	10.43	-4.77	-3.74
6	2.50	0.09	-0.09	1.	397.	0.	10.43	-4.77	-3.76
7	2.50	0.09	-0.09	1.	375.	0.	10.43	-4.77	-3.78
8	2.50	0.09	-0.09	1.	353.	0.	10.43	-4.77	-3.80
9	2.50	0.09	-0.09	1.	331.	0.	10.43	-4.77	-3.81
10	2.50	0.09	-0.09	1.	309.	0.	10.43	-4.77	-3.83
11	2.50	0.09	-0.09	1.	287.	0.	10.43	-4.77	-3.85
12	2.50	0.09	-0.09	1.	266.	0.	9.96	-4.55	-3.69
13	1.60	0.28	-0.10	1.	264.	0.	0.95	-1.88	-0.32
14	1.60	0.28	-0.11	1.	262.	0.	0.95	-1.88	-0.32
15	1.60	0.28	-0.12	1.	260.	0.	0.95	-1.88	-0.32
16	1.60	0.28	-0.12	1.	259.	0.	0.47	-0.94	-0.16
17	1.60	0.28	-0.13	1.	257.	0.	0.95	-1.88	-0.32
18	1.60	0.28	-0.14	1.	256.	0.	0.47	-0.94	-0.16
19	1.60	0.28	-0.15	509.	256.	0.07	-0.04	0.08	0.01
20	3.25	0.28	-0.16	551.	254.	0.11	-0.07	0.07	0.01
21	3.25	0.28	-0.17	541.	275.	0.11	-0.06	0.06	0.01
22	3.25	0.28	-0.18	556.	296.	0.11	-0.06	0.06	0.01
23	3.25	0.28	-0.18	523.	317.	0.11	-0.05	0.05	0.00
24	3.25	0.28	-0.19	521.	338.	0.11	-0.04	0.05	0.00
25	3.25	0.28	-0.20	488.	358.	0.11	-0.03	0.03	0.00
26	3.25	0.28	-0.21	515.	379.	0.11	-0.03	0.03	0.00
27	3.25	0.28	-0.22	563.	400.	0.11	-0.04	0.04	0.00
28	1.60	0.28	-0.23	604.	421.	0.10	-0.03	0.06	0.01
29	1.60	0.28	-0.23	496.	421.	0.10	-0.02	0.03	0.01
30	1.60	0.28	-0.24	523.	421.	0.10	-0.02	0.04	0.01

PRESSURE DROP AND THERMOCOUPLE CORRECTION FOR LITHIUM LOOP

LOOP COMPONENTS ARE INDEXED AS:
IX=0-2:HEATER IX=3:METERS IX=4:TEST ZONE
IX=4-11:ECON IX=11-18:RADIATOR
IX=19:COLD END IX=20-27:ECON IX=27-30:PUMPING
FOR TEST ZONE IX=4, ERROR IS CALCULATED FOR A
1 DEG CENTIGRADE TEMP DROP FOR LITHIUM STREAM PER METER
WITH LITHIUM AT APPROXIMATELY 100CM/S FLOW VELOCITY
TEMPERATURE DROP SHOWN FOR ACROSS PIPE WALL AND
FOR ACROSS LITHIUM BOUNDARY LAYER.
VALUES SHOWN ARE FOR INDEX, DIAMETER AND WALL THICKNESS(CM)
TEMPERATURE:STANDBY(APPROX.) & WHILE RUNNING(LINEARIZED)(C)
ELECTRICAL TRACE HEAT LOSS IN CAL/SEC/(CM OF PIPE)
AND LITHIUM HEAT LOSS (THROUGH WALL) CAL/SEC/CM
AND TEMPERATURE DROPS ACROSS STAINLESS AND BOUNDARY LAYER.(C)

X	D	W	PSI	TSTNBY	TEMP	QLOSS0	QLOSSR	ERR,SS	ERR,LI
1	6.00	0.60	-0.00	1.	490.	0.	-4.74	5.77	1.90
2	6.00	0.60	-0.00	1.	500.	0.	-4.74	5.77	1.89
3	1.35	0.12	-0.00	397.	500.	0.17	0.05	-0.06	-0.02
4	0.62	0.42	-0.08	397.	492.	0.	0.13	-0.77	-0.05
5	2.50	0.09	-0.08	1.	472.	0.	9.48	-4.34	-3.37
6	2.50	0.09	-0.08	1.	453.	0.	9.01	-4.12	-3.21
7	2.50	0.09	-0.09	1.	433.	0.	9.48	-4.34	-3.39
8	2.50	0.09	-0.09	1.	414.	0.	9.01	-4.12	-3.24
9	2.50	0.09	-0.09	1.	394.	0.	9.48	-4.34	-3.42
10	2.50	0.09	-0.09	1.	375.	0.	9.01	-4.12	-3.26
11	2.50	0.09	-0.09	1.	355.	0.	9.48	-4.34	-3.45
12	2.50	0.09	-0.09	1.	336.	0.	9.01	-4.12	-3.29
13	1.60	0.28	-0.10	1.	334.	0.	0.95	-1.88	-0.31
14	1.60	0.28	-0.11	1.	333.	0.	0.47	-0.94	-0.16
15	1.60	0.28	-0.11	1.	332.	0.	0.47	-0.94	-0.16
16	1.60	0.28	-0.12	1.	330.	0.	0.95	-1.88	-0.32
17	1.60	0.28	-0.13	1.	329.	0.	0.47	-0.94	-0.16
18	1.60	0.28	-0.14	1.	328.	0.	0.47	-0.94	-0.16
19	1.60	0.28	-0.15	509.	328.	0.07	-0.03	0.06	0.01
20	3.25	0.28	-0.16	551.	327.	0.11	-0.05	0.05	0.01
21	3.25	0.28	-0.16	541.	347.	0.11	-0.04	0.05	0.00
22	3.25	0.28	-0.17	556.	366.	0.11	-0.04	0.04	0.00
23	3.25	0.28	-0.18	523.	386.	0.11	-0.03	0.03	0.00
24	3.25	0.28	-0.19	521.	405.	0.11	-0.03	0.03	0.00
25	3.25	0.28	-0.20	488.	425.	0.11	-0.02	0.02	0.00
26	3.25	0.28	-0.21	515.	444.	0.11	-0.02	0.02	0.00
27	3.25	0.28	-0.21	563.	464.	0.11	-0.02	0.02	0.00
28	1.60	0.28	-0.22	604.	480.	0.10	-0.02	0.04	0.01
29	1.60	0.28	-0.23	496.	480.	0.10	-0.00	0.01	0.00
30	1.60	0.28	-0.24	523.	480.	0.10	-0.01	0.02	0.00

PRESSURE DROP AND THERMOCOUPLE CORRECTION FOR LITHIUM LOOP

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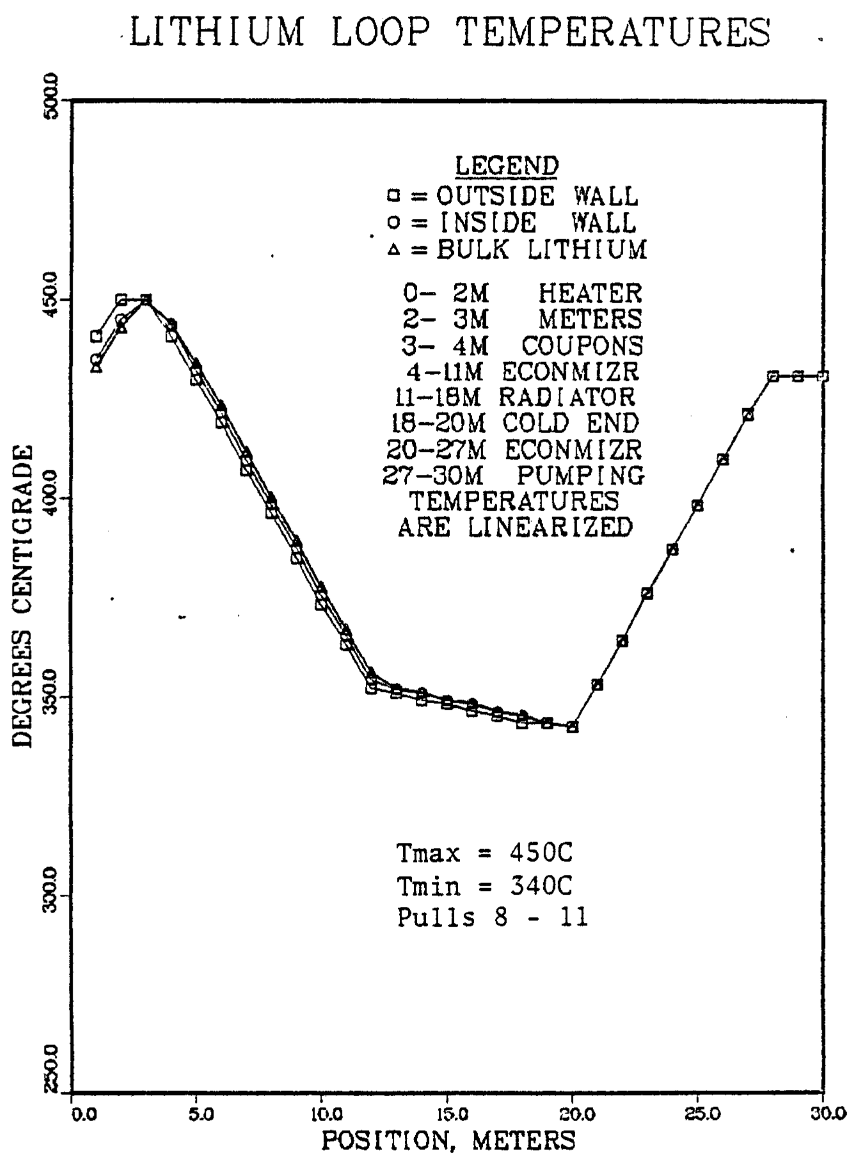
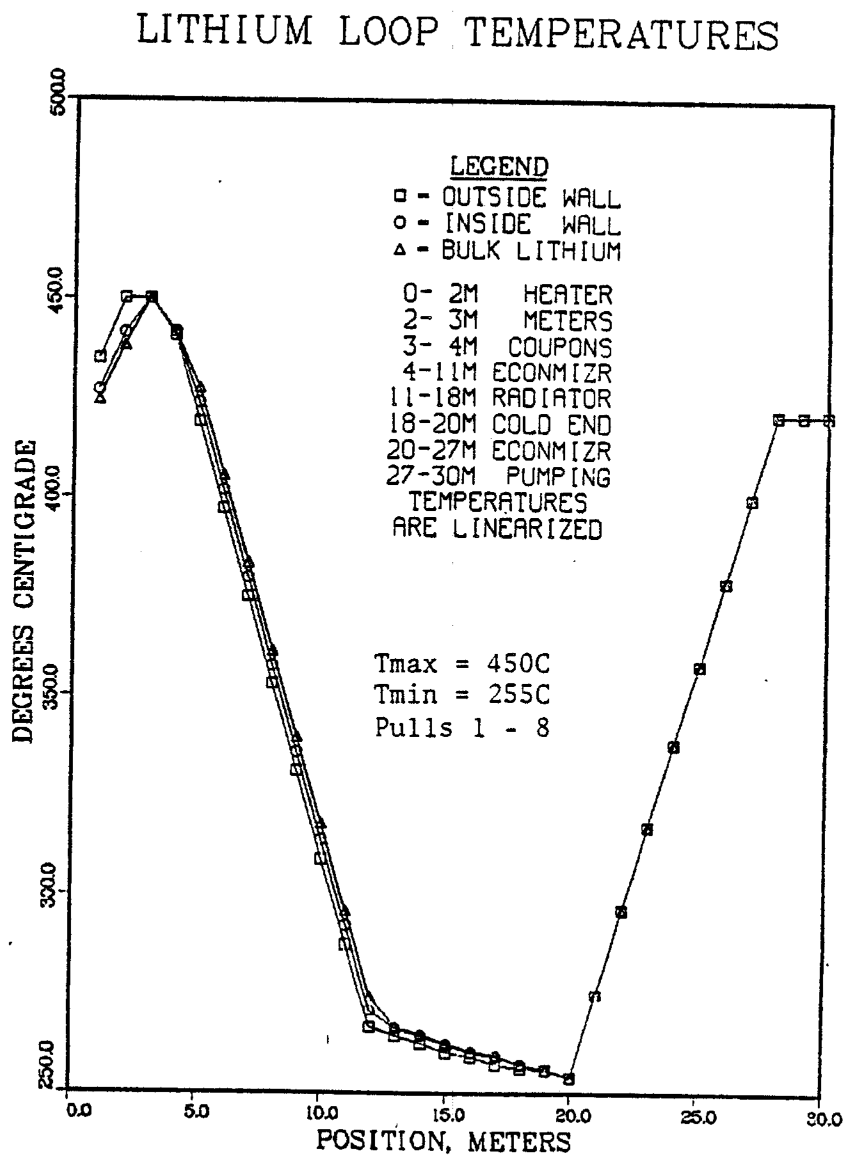
WITH LITHIUM AT APPROXIMATELY 100CM/S FLOW VELOCITY
TEMPERATURE DROP SHOWN FOR ACROSS PIPE WALL AND
FOR ACROSS LITHIUM BOUNDARY LAYER.
VALUES SHOWN ARE FOR INDEX, DIAMETER AND WALL THICKNESS(CM)
TEMPERATURE:STANDBY(APPROX.) & WHILE RUNNING(LINEARIZED)(C)
ELECTRICAL TRACE HEAT LOSS IN CAL/SEC/(CM OF PIPE)
AND LITHIUM HEAT LOSS (THROUGH WALL) CAL/SEC/CM
AND TEMPERATURE DROPS ACROSS STAINLESS AND BOUNDARY LAYER.(C)

X	D	W	PSI	TSTNBY	TEMP	QLOSS0	QLOSSR	ERR,SS	ERR,LI
1	6.00	0.60	-0.00	1.	441.	0.	-4.74	5.77	1.92
2	6.00	0.60	-0.00	1.	450.	0.	-4.27	5.20	1.72
3	1.35	0.12	-0.02	397.	450.	0.17	0.03	-0.03	-0.01
4	0.62	0.42	-0.76	397.	441.	0.	0.48	-2.74	-0.11
5	2.50	0.09	-0.76	1.	430.	0.	5.21	-2.39	-1.87
6	2.50	0.09	-0.77	1.	419.	0.	5.21	-2.39	-1.87
7	2.50	0.09	-0.77	1.	407.	0.	5.69	-2.60	-2.05
8	2.50	0.09	-0.77	1.	396.	0.	5.21	-2.39	-1.88
9	2.50	0.09	-0.77	1.	385.	0.	5.21	-2.39	-1.89
10	2.50	0.09	-0.77	1.	373.	0.	5.69	-2.60	-2.06
11	2.50	0.09	-0.77	1.	363.	0.	4.74	-2.17	-1.72
12	2.50	0.09	-0.77	1.	352.	0.	5.21	-2.39	-1.90
13	1.60	0.28	-0.78	1.	351.	0.	0.47	-0.94	-0.16
14	1.60	0.28	-0.79	1.	349.	0.	0.95	-1.88	-0.31
15	1.60	0.28	-0.80	1.	348.	0.	0.47	-0.94	-0.16
16	1.60	0.28	-0.80	1.	346.	0.	0.95	-1.88	-0.31
17	1.60	0.28	-0.81	1.	345.	0.	0.47	-0.94	-0.16
18	1.60	0.28	-0.82	1.	343.	0.	0.95	-1.88	-0.31
19	1.60	0.28	-0.83	509.	343.	0.07	-0.03	0.05	0.01
20	3.25	0.28	-0.84	551.	342.	0.11	-0.05	0.05	0.00
21	3.25	0.28	-0.85	541.	353.	0.11	-0.04	0.04	0.00
22	3.25	0.28	-0.85	556.	364.	0.11	-0.04	0.04	0.00
23	3.25	0.28	-0.86	523.	376.	0.11	-0.03	0.04	0.00
24	3.25	0.28	-0.87	521.	387.	0.11	-0.03	0.03	0.00
25	3.25	0.28	-0.88	488.	398.	0.11	-0.02	0.02	0.00
26	3.25	0.28	-0.89	515.	410.	0.11	-0.03	0.03	0.00
27	3.25	0.28	-0.90	563.	421.	0.11	-0.03	0.03	0.00
28	1.60	0.28	-0.90	604.	431.	0.10	-0.03	0.06	0.01
29	1.60	0.28	-0.91	496.	431.	0.10	-0.01	0.03	0.00
30	1.60	0.28	-0.92	523.	431.	0.10	-0.02	0.04	0.01


LITHIUM LOOP TEMPERATURES
LEGEND
□ = OUTSIDE WALL
○ = INSIDE WALL
△ = BULK LITHIUM
0- 2M HEATER
2- 3M METERS
3- 4M COUPONS
4-11M ECONMIZR
11-18M RADIATOR
18-20M COLD END
20-27M ECONMIZR
27-30M PUMPING
TEMPERATURES
ARE LINEARIZED
Tmax = 450C
Tmin = 340C
Pulls 8 - 11
DEGREES CENTIGRADE
250.0
300.0
350.0
400.0
450.0
500.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
POSITION, METERS


LITHIUM LOOP TEMPERATURES
LEGEND
□ - OUTSIDE WALL
○ - INSIDE WALL
△ - BULK LITHIUM
0- 2M HEATER
2- 3M METERS
3- 4M COUPONS
4-11M ECONMIZR
11-18M RADIATOR
18-20M COLD END
20-27M ECONMIZR
27-30M PUMPING
TEMPERATURES
ARE LINEARIZED
Tmax = 450C
Tmin = 255C
Pulls 1 - 8
DEGREES CENTIGRADE
500.0
450.0
400.0
350.0
300.0
250.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
POSITION, METERS

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C       LATEST REVISION JUNE 3, 1980
C       DON BAUER  UW MADISON WISCONSIN 53706
C       CHEM ENGRG/NUCL ENGRG DEPT
C       LITHIUM LOOP EXPERIMENT
C
C
        PROGRAM COEFF(OUTCOE,TAPE6=OUTCOE,OUTPUT,TAPE59=OUTPUT)
        CALL CHANGE(4R+COE)
        CALL FR80ID("COEFF",1,3)
        CALL KEEP80(1,3)
        CALL PLTS
        DIMENSION X(20),Y(20)
        REAL K,KCHEM
        WRITE(59,1)
 1      FORMAT(" ENTER NUMBER OF COMPARISONS TO BE MADE",/,
       +" OF CHEMICAL RESISTANCE IN SERIES WITH MASS TRANSFER",
       +" RESISTANCE.",/," EXAMPLE: ENTER 3 AND GET EFFECT FOR",
       +/," CHEM COEFFICIENT = 1/4, 1/2, 1/1, 2/1, 4/1, AND INFINITY",
       +/," TIMES SMALLEST MASS TRANSFER COEFFICIENT")
        READ(59,2)NUM
 2      FORMAT(I1)
        DO 30 IVP=1,2
C       IVP=1 FOR VELOCITY,  IVP=2 FOR POSITION DEPENDENCE
        DO 25 ITL=1,3
C       ITL=1 LAMINAR .33, =2 ENTRANCE .5  =3 TURBULENT .8
        IF(IVP.EQ.2.AND.ITL.EQ.3)GO TO 25
C       DONT GRAPH POSITION DEPENDENCE FOR TURBULENT CASE
        CALL NOBRDR
        CALL MX1ALF("STAND",">")
         CALL MX2ALF("INSTR","<")
        IF(IVP.EQ.1)CALL TITLE("MASS TRANSFER WITH CHEM REACTION$",100,
       +"RELATIVE VELOCITY, V$",100,
       +"RELATIVE K<L>APPARENT<LX>=(1/K'' + 1/K<L>WI<LX>)<E>-1<EX>
       +              .$",100,6.,8.)
        IF(IVP.EQ.2)CALL TITLE("MASS TRANSFER WITH CHEM REACTION$",100,
       +"RELATIVE X/D POSITION$",100,
       +"RELATIVE K<L>APPARENT<LX>=(1/K'' + 1/K<L>WI<LX>)<E>-1<EX>$",
       +100,6.,8.)
        CALL DFRAME
        IF(IVP.EQ.1)CALL LOGLOG(1.,8.,.2,8.)
C       IF(IVP.EQ.1)CALL GRID(5,5)
        IF(IVP.EQ.2)CALL GRAF(0.,10.,80.,0.,.1,0.6)
        DO 20 IMUL=1,(2*NUM)
        KEXP=IMUL-(NUM+1)
        AMUL=2.**KEXP
        IF(IMUL.EQ.1)AMUL=100000.
        KCHEM=AMUL
        IF(IVP.EQ.2)GO TO 14
        IF(IMUL.NE.1)GO TO 13
        WRITE(6,12)
 12     FORMAT(//////////,17X,"APPARENT VELOCITY EFFECT WHEN A CHEMICAL
       + RESISTANCE",/,17X,"IS IN SERIES WITH LIQUID BOUNDARY LAYER",
       +" RESISTANCE",/)
        NPTS=4
        CALL MESSAG("VELOCITY EFFECT$",100,.2,7.75)
        IF(ITL.EQ.1)CALL MESSAG("LAMINAR 1/3 POWER K<L>WI<LX>$",100,
       +.35,7.5)
        IF(ITL.EQ.2)CALL MESSAG("ENTRANCE 1/2 POWER K<L>WI<LX>$",100,
       +.35,7.5)
        IF(ITL.EQ.3)CALL MESSAG("TURBULENT .8 POWER K<L>WI<LX>$",100,
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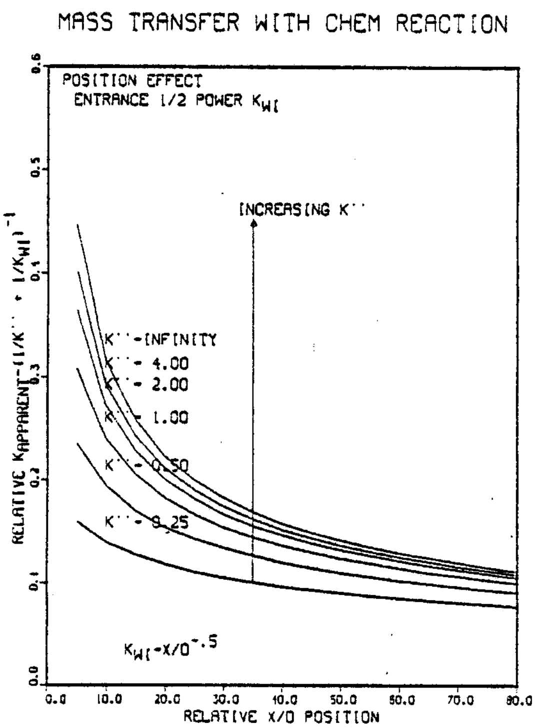
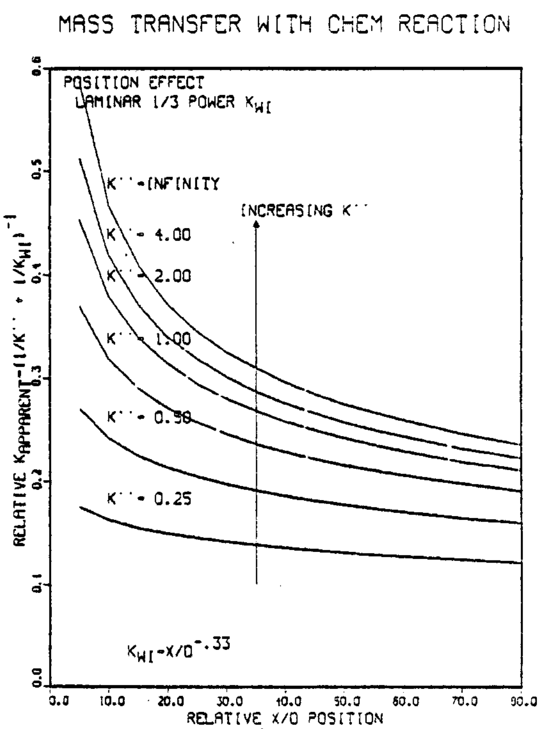
     +.35,7.5)
13    DO 15 IV=1,4
      RIV=IV
      X(IV)=RIV
      IF(ITL.EQ.1)Y(IV)=1./(1./KCHEM+RIV**(-.33))
      IF(ITL.EQ.2)Y(IV)=1./(1./KCHEM+RIV**(-.5))
      IF(ITL.EQ.3)Y(IV)=1./(1./KCHEM+RIV**(-.8))
15    CONTINUE
      GO TO 16
14    NPTS=16
      IF(IMUL.EQ.1)CALL MESSAG("POSITION EFFECT$",100,.2,7.75)
      IF(IMUL.EQ.1.AND.ILT.EQ.1)CALL MESSAG("1/3 POWER K<L>WI<LX>$",
     +100,.35,7.25)
      IF(IMUL.EQ.1.AND.ILT.EQ.2)CALL MESSAG("1/2 POWER K<L>WI<LX>$",
     +100,.35,7.25)
19    DO 16 ILD=1,16
      IL=ILD*5
      X(ILD)=IL
      IF(ITL.EQ.1)Y(ILD)=1./(1./KCHEM+X(ILD)**.33)
      IF(ITL.EQ.2)Y(ILD)=1./(1./KCHEM+X(ILD)**.5)
16    CONTINUE
      IF(IMUL.NE.1)GO TO 17
      IF(ITL.EQ.1)CALL MESSAG("LAMINAR 1/3 POWER K<L>WI<LX>$",100,
     +.35,7.5)
      IF(ITL.EQ.2)CALL MESSAG("ENTRANCE 1/2 POWER K<L>WI<LX>$",100,
     +.35,7.5)
17    CALL CURVE(X,Y,NPTS,0)
      NWR=3
      IF(IVP.EQ.2)NWR=2
      XPOS=XPOSN(X(NWR),Y(NWR))
      YPOS=YPOSN(X(NWR),Y(NWR))
      CALL MESSAG("K''=$",100,XPOS,YPOS+.2)
      IF(KCHEM.GE.100.)CALL MESSAG("INFINITY$",100,"ABUT","ABUT")
      IF(KCHEM.LT.100)CALL REALNO(KCHEM,2,"ABUT","ABUT")
      IF(IVP.EQ.2)GO TO 20
      CHORD=(ALOG(Y(4))-ALOG(Y(1)))/ALOG(4.)
      IF(ITL.EQ.1)WRITE(6,161)KCHEM,CHORD
      IF(ITL.EQ.2)WRITE(6,162)KCHEM,CHORD
      IF(ITL.EQ.3)WRITE(6,163)KCHEM,CHORD
161   FORMAT(17X,"1/3 POWER, K'' =",F7.3,"  SLOPE=",F5.3)
162   FORMAT(17X,"1/2 POWER, K'' =",F7.3,"  SLOPE=",F5.3)
163   FORMAT(17X,"8/10 POWER, K'' =",F7.3,"  SLOPE=",F5.3)
      IF(IMUL.EQ.1)CALL MESSAG("SLOPES=$",100,.1,1.1)
      IF(IMUL.NE.1)CALL REALNO(CHORD,2,((IMUL)*.7),1.1)
      IF(ITL.EQ.1)CHORD=.33
      IF(ITL.EQ.2)CHORD=.5
      IF(ITL.EQ.3)CHORD=.8
      IMM=IMUL+1
      IF(IMUL.EQ.(2*NUM))CALL REALNO(CHORD,2,IMM*.7,1.1)
20    CONTINUE
      IF(IVP.EQ.2)GO TO 21
      XS=XPOSN(5.,.2)
      YS=YPOSN(5.,.2)
      CALL MESSAG("5$",100,XS,YS-.3)
      X(1)=1.5
      X(2)=1.5
      Y(1)=.4
      Y(2)=1.2
      GO TO 22
21    X(1)=35.
```

```
      X(2)=35.
      Y(1)=.1
      Y(2)=.45
22    CALL CURVE(X,Y,2,0)
      CALL MARKER(2)
      CALL CURVE(X(2),Y(2),1,1)
      XS=XPOSN(X(2),Y(2))-.2
      YS=YPOSN(X(2),Y(2))+.1
      CALL MESSAG("INCREASING K''$",100,XS,YS)
      IF(IVP.EQ.1.AND.ITL.EQ.1)
     +CALL MESSAG("K<L>WI<LX>=VEL<E>.33<EX>$",100,1.0,1.5)
      IF(IVP.EQ.1.AND.ITL.EQ.2)
     +CALL MESSAG("K<L>WI<LX>=VEL<E>.5<EX>$",100,1.0,1.5)
      IF(IVP.EQ.1.AND..ITL.EQ.3)
     +CALL MESSAG("K<L>WI<LX>=VEL<E>.8<EX>$",100,1.0,1.5)
      IF(IVP.EQ.2.AND.ITL.EQ.1)
     +CALL MESSAG("K<L>WI<LX>=X/D<E>-.33<EX>$",100,1.0,.4)
      IF(IVP.EQ.2.AND.ITL.EQ.2)
     +CALL MESSAG("K<L>WI<LX>=X/D<E>-.5<EX>$",100,1.0,.4)
      IF(IVP.EQ.2.AND.ITL.EQ.3)
     +CALL MESSAG("K<L>WI<LX>=X/D<E>-.8<EX>$",100,1.0,.4)
25    CALL ENDPL(0)
30    CONTINUE
      CALL DONEPL
      CALL PLOTE
      CALL QUIT(1)
      END
```



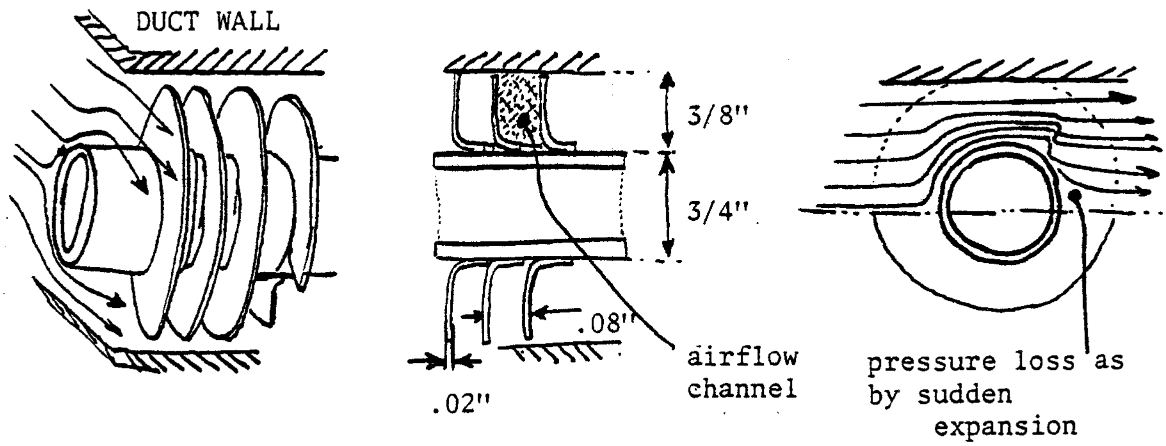


```
APPARENT VELOCITY EFFECT WHEN A CHEMICAL RESISTANCE
IS IN SERIES WITH LIQUID BOUNDARY LAYER RESISTANCE
1/3 POWER, KCHEM =  *.    *LOWEST KC; SLOPE=-.330
1/3 POWER, KCHEM =  0.004*LOWEST KC; SLOPE=0.001
1/3 POWER, KCHEM =  0.008*LOWEST KC; SLOPE=0.002
1/3 POWER, KCHEM =  0.016*LOWEST KC; SLOPE=0.004
1/3 POWER, KCHEM =  0.031*LOWEST KC; SLOPE=0.008
1/3 POWER, KCHEM =  0.062*LOWEST KC; SLOPE=0.016
1/3 POWER, KCHEM =  0.125*LOWEST KC; SLOPE=0.030
1/3 POWER, KCHEM =  0.250*LOWEST KC; SLOPE=0.055
1/3 POWER, KCHEM =  0.500*LOWEST KC; SLOPE=0.094
1/3 POWER, KCHEM =  1.000*LOWEST KC; SLOPE=0.146
1/3 POWER, KCHEM =  2.000*LOWEST KC; SLOPE=0.202
1/3 POWER, KCHEM =  4.000*LOWEST KC; SLOPE=0.251
1/3 POWER, KCHEM =  8.000*LOWEST KC; SLOPE=0.285
1/3 POWER, KCHEM = 16.000*LOWEST KC; SLOPE=0.306
1/3 POWER, KCHEM = 32.000*LOWEST KC; SLOPE=0.317
1/3 POWER, KCHEM = 64.000*LOWEST KC; SLOPE=0.324
1/3 POWER, KCHEM =128.000*LOWEST KC; SLOPE=0.327
1/3 POWER, KCHEM =256.000*LOWEST KC; SLOPE=0.328
APPARENT VELOCITY EFFECT WHEN A CHEMICAL RESISTANCE
IS IN SERIES WITH LIQUID BOUNDARY LAYER RESISTANCE
1/2 POWER, KCHEM =  *.    *LOWEST KC; SLOPE=0.500
1/2 POWER, KCHEM =  0.004*LOWEST KC; SLOPE=0.001
1/2 POWER, KCHEM =  0.008*LOWEST KC; SLOPE=0.003
1/2 POWER, KCHEM =  0.016*LOWEST KC; SLOPE=0.006
1/2 POWER, KCHEM =  0.031*LOWEST KC; SLOPE=0.011
1/2 POWER, KCHEM =  0.062*LOWEST KC; SLOPE=0.022
1/2 POWER, KCHEM =  0.125*LOWEST KC; SLOPE=0.041
1/2 POWER, KCHEM =  0.250*LOWEST KC; SLOPE=0.076
1/2 POWER, KCHEM =  0.500*LOWEST KC; SLOPE=0.132
1/2 POWER, KCHEM =  1.000*LOWEST KC; SLOPE=0.208
1/2 POWER, KCHEM =  2.000*LOWEST KC; SLOPE=0.292
1/2 POWER, KCHEM =  4.000*LOWEST KC; SLOPE=0.368
1/2 POWER, KCHEM =  8.000*LOWEST KC; SLOPE=0.424
1/2 POWER, KCHEM = 16.000*LOWEST KC; SLOPE=0.459
1/2 POWER, KCHEM = 32.000*LOWEST KC; SLOPE=0.478
1/2 POWER, KCHEM = 64.000*LOWEST KC; SLOPE=0.489
1/2 POWER, KCHEM =128.000*LOWEST KC; SLOPE=0.494
1/2 POWER, KCHEM =256.000*LOWEST KC; SLOPE=0.497
APPARENT VELOCITY EFFECT WHEN A CHEMICAL RESISTANCE
IS IN SERIES WITH LIQUID BOUNDARY LAYER RESISTANCE
8/10 POWER, KCHEM =  *.    *LOWEST KC; SLOPE=0.800
8/10 POWER, KCHEM =  0.004*LOWEST KC; SLOPE=0.002
8/10 POWER, KCHEM =  0.008*LOWEST KC; SLOPE=0.004
8/10 POWER, KCHEM =  0.016*LOWEST KC; SLOPE=0.007
8/10 POWER, KCHEM =  0.031*LOWEST KC; SLOPE=0.015
8/10 POWER, KCHEM =  0.062*LOWEST KC; SLOPE=0.029
8/10 POWER, KCHEM =  0.125*LOWEST KC; SLOPE=0.056
8/10 POWER, KCHEM =  0.250*LOWEST KC; SLOPE=0.104
8/10 POWER, KCHEM =  0.500*LOWEST KC; SLOPE=0.182
8/10 POWER, KCHEM =  1.000*LOWEST KC; SLOPE=0.294
8/10 POWER, KCHEM =  2.000*LOWEST KC; SLOPE=0.427
8/10 POWER, KCHEM =  4.000*LOWEST KC; SLOPE=0.554
8/10 POWER, KCHEM =  8.000*LOWEST KC; SLOPE=0.653
8/10 POWER, KCHEM = 16.000*LOWEST KC; SLOPE=0.719
8/10 POWER, KCHEM = 32.000*LOWEST KC; SLOPE=0.757
8/10 POWER, KCHEM = 64.000*LOWEST KC; SLOPE=0.778
8/10 POWER, KCHEM =128.000*LOWEST KC; SLOPE=0.789
8/10 POWER, KCHEM =256.000*LOWEST KC; SLOPE=0.794
```

APPENDIX Q. RADIATOR CALCULATIONS

Heat Transfer Estimations

Air Side Pressure Drop



1. Air density: ideal gas at 200F; 660R.

$$\rho = \frac{29 lb/mol}{359 ft^3/mol} \; \frac{492R}{660R} = .06 lb/ft^3 = \rho$$

2, Air viscosity: 200F ≃ 100C (see p. 8, Bird)

$$\mu = .0217 \text{ cp} \times \frac{2.42 \text{ lb/ft/hr}}{\text{cp}} = .0525 \text{ lb/ft/hr} = \mu$$

3. Maximum heat load

$$Q = 20kW \times \frac{kJ/s}{kW} \times \frac{kcal}{4.187kJ} \times \frac{3.96BTU}{kcal} \times \frac{3600s}{hr} = 68{,}210 BTU/hr = Q$$

Of this amount of heat, perhaps half would actually have to be transferred from the finned pipes in the radiator; the remainder would be lost to the surroundings through the enclosure walls by radiation, convection and conduction.

4. Diameter of finned pipe(without fins)

$$D = 0.83 \text{inches} \times \frac{ft}{12in} = .069 ft = D$$

5. Equivalent diameter of finned region slits. (See diagram above).

$$D_e = 4 \times Area/Perimeter = \frac{4(.08 \times .375)}{(2 \times .375)} \text{inch} \times \frac{ft}{12in} = .0133 ft = D_e$$

6. Maximum air mass flow rate at temperature rise of 100 degrees F:

$$M = \text{(approx)}\ 72{,}000\frac{BTU}{hr} \times \frac{lb\ ^\circ F}{.25BTU} \times \frac{1}{100^\circ F} = 2880\ lb/hr = M$$

7. Flow area of slits, per pass:

$$A_f = \frac{4ft}{pass} \times \frac{12in}{ft} \times \frac{10fin}{inch} \times \frac{2slit}{fin} \times \frac{(.08x.375)}{12x12}\frac{ft^2}{slit} = \frac{.2ft^2}{pass} = A_f$$

8. Mass velocity of air;

$$G = \frac{\text{mass flow rate } M}{\text{flow area } A_f} = \frac{2880lb/hr}{.2ft^2} = \frac{14{,}400\ lb}{ft^2\ hr} = G$$

9. Velocity of air:

$$V = \frac{\text{mass velocity } G}{\text{air density } \rho} = \frac{14{,}400\ lb/ft^2\ /hr}{.06\ lb/ft^3} = 2.4x10^5\ ft/hr = V$$
$$= 67\ ft/s = V$$

10. Reynolds number for flow past tube (not including effect of fins)

$$Re_t = \frac{D\ V\ \rho}{\mu} = \frac{.069ft \times 2.4x10^5 ft/hr \times .06lb/ft^3}{.05lb/ft/hr} = 20{,}000 = Re_t$$

11. Reynolds number for flow through slit:

$$Re_s = \frac{De \times V \times \rho}{\mu} = \frac{.0133ft\ \ 2.4x10^5 ft/hr\ \ .06lb/ft^3}{.05lb/ft/hr} = 3830 = Re_s$$

12. Friction factor for flow through slit:

$f \leq 0.01$ (page 186, Bird).

13. Surface area of fins, per pass:

$$A_s = \frac{4ft}{pass}\ \frac{12in}{ft}\ \frac{10fin}{inch}\ \frac{2sides}{fin}\ \frac{3.14(1.5^2-.75^2)ft^2}{144\ \ \ 4\ \ \ side} = \frac{8.83ft^2}{pass} = A_s$$

14. Volumetric flow rate of air :

$$\text{Vol} = \frac{\text{mass flow rate M}}{\text{air density } \rho} = \frac{2880\text{lb/hr}}{.06\text{lb/ft}^3} = 48{,}000\text{ft}^3\text{/hr} = \text{Vol}$$

$$= 800 \text{ ft}^3\text{/min} = \text{Vol}$$

$$= 13.33 \text{ ft}^3\text{/s} = \text{Vol}$$

15. Pressure drop due to flow through slits:

Work=VolumeΔP = Force x displacement

Power= Volume/time ΔP = Vol ΔP = Force x displacement/time

Vol ΔP = (f x Kinetic energy x surface area) x(velocity)

Vol ΔP = $(f\ \rho\ V^2/2\quad A_s)\ V$

$$\frac{13.33\text{ft}^3}{\text{sec}} \Delta P = \frac{.01}{2}\ \frac{.06\text{lb}}{\text{ft}^3}\ \frac{67^3\ \text{ft}^3}{\text{sec}^3}\ \ 8.83\text{ft}^2 = \frac{796\text{lb ft}^2}{\text{sec}^3}$$

$$13.33\ \Delta P = \frac{796\text{ lb}}{\text{ft sec}^2} \times \frac{\text{sec}^2\text{lbf}}{32.17\text{lb-ft}} \times \frac{\text{ft}^2}{144\text{in}^2} = \frac{.172\text{ lbf}}{\text{in}^2}$$

ΔP = .052 lbf/in^2 per pass

= .21 lbf/in^2 total due to fins

$$\Delta P\text{, water gauge} = .21\ \frac{\text{lbf}}{\text{in}^2}\ \frac{33\text{x}12\text{ inch of water}}{14.7\text{ lbf/in}^2} = 1.39\text{ inH}_2\text{O}$$

16. Pipe surface area per pass:

$$\frac{4\text{ft}}{\text{pass}}\quad 3.14\quad .069\text{ft} = .87\text{ft}^2 \text{ of pipe surface per pass}$$

Total surface area per pass .87+8.83=9.7ft^2

Fins make up about 90% of area for heat transfer

17. Pressure drop due to flow past pipe (without fins):

Treat pressure drop as purely due to enlargement loss after air goes by pipe.

$$\Delta P = \rho\ K_e\ (V^2/2g_c) \qquad K_e = (1.-A1/A2)^2 = (1.-.5)^2 = .25$$

$$\Delta P = \frac{.06\text{ lb}}{\text{ft}^3}\ \frac{.25}{2}\ \frac{67^2\ \text{ft}^2}{32.17\text{lb-ft}}\ (\text{lbf-sec}^2) = 1.05\text{lbf/ft}^2 \text{ per pass}$$

$$\text{Water gauge } \Delta P = 4 \text{ passes } \frac{1.05\text{lbf}}{\text{ft}^2\text{ pass}}\ \frac{(33\text{x}12\text{ inch H}_2\text{O})\ \text{ft}^2}{14.7\text{lbf/in}^2\quad 144\text{ in}^2} = .78\text{inH}_2\text{O}$$

18. Total pressure drop due to fins and pipes:

ΔP = 1.39 + .78 = 2.17 inches of water

Since Reynolds number is 3800 and Prandtl number is 0.7, the momentum entrance length is x/b = 3800/20= 190; b=.04inches, so x is about 8" and the flow is still developing as it goes through the slits. The friction factor would therefore be larger than the value used above. However, the thermal entrance length x=b Re Pr/20 is also longer than the distance through the slits, so that heat transfer coefficient will be somewhat larger than calculated in the following analysis, and this will somewhat offset the increased friction factor. Less flow of air (lower pressure drop) will be needed due to the higher heat transfer coefficient.

19. Necessary heat transfer coefficient:

$$U = Q/(A\ \Delta T) = \frac{68000 BTU/hr}{4(9.5ft^2)\ \Delta T}$$

Logarithmic delta temperature: Assume air enters at 100F and exits at 200F. Lithium enters at 430F and exits at 390F.

$$\Delta T_{ln} = \frac{(430-200) - (390-100)}{\ln[430-200)/(390-100)]} = \frac{230-290}{\ln[230/290]} = 259F$$

$$U = Q/(A\ \Delta T) = \frac{68000 BTU}{hr} \frac{1}{38ft^2} \frac{1}{259F} = \frac{6.9\ BTU}{hr\ ft^2\ F}$$

20. Estimated air side heat transfer coefficient

For slits, Reynolds number is 3830.

$h/C_pG \quad Pr^{2/3} (\mu_b/\mu_w)^{-.14} \geq .003$ (page 400, Bird).

$$h \frac{lb\ °F}{.25BTU} \frac{ft^2\ hr}{14400lb} (.7)^{2/3} (T_b/T_w)^{-.07} \geq .003$$

$$\frac{h\ ft^2 hr°F}{3600\ BTU} .79 \quad [(460+200)/(460+400)]^{-.07} \geq .003$$

$h = 13.4\ BTU/hr/ft^2/°F$ @ 14400lb/hr $(800ft^3/min)$

If the flow is half as much, the right hand side is still at least .003, G is half as much, so h is about half, or 7 BTU/$(hrft^2°F)$

21. Correction for fin efficiency:

Most of the heat transfer area (90%) is in the fin surfaces. The value of the heat transfer coefficient must be reduced slightly to take into account the fin efficiency.

From page 37 of Extended Surfaces by Kraus:

$$\phi = (r_c - r_o)^{3/2} (2\dot{h}/kA)^{1/2} \quad \text{A being thickness x(rc-ro)}$$

$$\phi = \left(\frac{.75-.375}{12}\right)^{3/2-1/2} \left[\frac{2\ 13\ \text{BTU/hr/ft}^2/°\text{F}}{26\ \text{BTU /hr/ft/°F}} \quad \frac{12}{.02\ \text{ft}}\right]^{1/2}$$

ϕ=.76; rc/ro=2, therefore efficiency η= .80.

At flow rate of 800CFM, coefficient is .8x.3=10.4 BTU/hr/ft^2/°F.
At flow rate of 400CFM, ϕ is .76(6.7/13)$^{.5}$= .54; η=0.87.
At flow rate of 400CFM, coefficient is .87x6.7=5.8BTU/hr/ft^2/°F.

22. Summary

Transfer of 20KW requires U (approximately equal to h; lithium side coefficient will be high and stainless wall should also be low resistance) to be 6.9BTU/(hr-ft^2-°F); transfer of 10KW requires U of 3.5.

At 800 CFM, h can be 10.4 BTU/(hr-ft^2-°F)
At 400 CFM, h can be 5.8 " "

At 800 CFM, ΔP is about 2.2 inches of water.
At 400 CFM, pressure drop would be about .6 inches of water.

The pressure drop for 800 CFM may be slightly high, since the velocity is taken to be at its highest value at all points along the fins. The pressure drop due to the pipe is approximated as an enlargement loss as the air passes the pipe.

APPENDIX R. PROGRAM COSINE

Fit Solubility with Cosine Series

(Uses IMSL, Inc. routines BCOVM, RLMUL;
also graphics routines from DISSPLA)

(Uses subroutine TE from appendix U).

PROGRAM SOLGRAPH

This program draws van t'Hoff
(ln[solubility] vs. 1/T) graph
for iron solubility in lithium.

```
C      LATEST REVISION APRIL 5, L980
C      DON BAUER UW MADISON NUCLEAR ENGR/CHEM ENGR LITHIUM LOOP EXPERIMENT
       PROGRAM COSINE(COSDATA,TAPE5=COSDATA,OUTFIL,TAPE6=OUTFIL,PRINT,
      +OUTPUT,TAPE9=OUTPUT)
C      PROGRAM TO DETERMINE SERIES OF COSINES TO FIT WALL CONCENTRATION
C      FOR THE LITHIUM LOOP.
C      WRITTEN BY DON BAUER,   SEPTEMBER 20, 1979
C      UNIVERSITY OF WISCONSIN MADISON WISCONSIN 53706
C
C      SET UP DROPFILE FOR DEBUGGING, SET UP PLOTTING ROUTINES
       CALL CHANGE(4R+COS)
       CALL KEEP80(1,3)
       CALL FR80ID("EXAMPLE",1,3)
       CALL PLTS
       INTEGER DOPT,TOPT
C
C
       DIMENSION SCALE(10), XALL(35,10),XEXP(35),YEXP(35)
       DIMENSION YDR(35),  XRAD(35), X(35,10),NBR(6),TEMP(10)
       DIMENSION  XM(10),VCV(100),VARB(50),XYBAR(10),ANOVA(70),B(10,7)
       DIMENSION SCALEA(10), XX(35,10), AREAD(20),A(20,5)
       COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
      +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
      +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
      +NNLAST,ALN17.26,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
      +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
      +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
      +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
      +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
      +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
      +,ZEXTRA(5),ABCD
C
       DATA NBR/6*1/
C      A IS LOOP PARAMETER INFORMATION.
       DATA A/623.,100.,2255.,1.6,2957.,1.,49.,-17.2.,14200.,0.,100.,
      +9*0.,669.5,53.5,2255.,1.6,2957.,1.,49.,-17.2.,14200.,0.,100.,9*0.,
      +723.,88.5.,0.,2.2,1500.,1.,58.,-17.2.,14200.,0.,50.,9*0.,
      +773.,100.,0.,2.2,232.,1.,4.23,-17.2.,14200.,1.27,8.,29*0./
       A(8,1)=-21.
       A(9,1)=14200.
C***************DATA EXAMPLE***************************
C*****************************************************
C TYPE1GRFS3PTS06DIS+1    150.
C TYPE1GRFS3PTS06DIS+2    150.
C      ITYPE =1 USE COSINES  =2 USE EXPONENTIALS
C      IGRAPHS = MAXIMUM NUMBER OF TERMS (COSINES)
C      IPTS = NUMBER OF POINTS USED
C      IDIST=1 DISTRIBUTE POINTS EVENLY
C      IDIST=2,3,ETC. PROGRESSIVELY MORE POINTS CONCENTRATED AT THETA=0
C      IDIST IS POSITIVE, DISTRIBUTION BY SQUARE, CUBE ETC
C      IDIST IS NEGATIVE, DISTRIBUTION BY EXP(-SQUARE),EXP(-CUBE),ETC.
C      SHIFT =(CM) LOOP LOCATION OF THETA = ZERO RADIANS.
C*******************************************************************
C*******************************************************************
1000   READ(5,100)ITYPE,IGRAFS,IPTS,IDIST,SHIFT
       IF(ITYPE.EQ.00)CALL DONEPL
       IF(ITYPE.EQ.0)CALL QUIT(1)
100    FORMAT(4X,I1,4X,I1,3X,I2,3X,I2,F10.0)
C
       LNUM=1
```

```
          TOPT=2
          X=0
          THIGH=-1.
    2     X=X+1
          IF(TE(X).GT.THIGH)XHIGH=X
          IF(TE(X).GT.THIGH)THIGH=TE(X)
          IF(X.LT.A(5,LNUM))GO TO 2
          IF(SHIFT.NE.0)XHIGH=SHIFT
          DO 20 INUM=1,30
          XT=(INUM-1.)/30.*A(5,LNUM)
          XSOL=XT+XHIGH
          IF(XSOL.GE.A(5,LNUM))XSOL=XSOL-A(5,LNUM)
          T=TE(XSOL)
          XEXP(INUM)=XT/A(5,LNUM)*2.*3.14159
          RADIAN=XT/A(5,LNUM)*2.*3.14159
    C
    C
          DO 19 ICOS=1,IGRAFS
    19    XALL(INUM,ICOS)=COS(ICOS*RADIAN)
          SOL=EXP(A(8,LNUM))*EXP(A(9,LNUM)/1.987*(1./773.-
         +1./T))
    20    YEXP(INUM)=SOL*1.E+10
          SHIFTR=XHIGH/A(5,LNUM)*3.14159*2.
    C     RADIANS SHIFT(PHASE ANGLE)
          DO 3 INUM=1,IPTS
          IF(IDIST.GT.0.AND.
         +INUM.LE.(IPTS/2.))XT=.5*A(5,LNUM)*((INUM-1.)/IPTS*2.)**IDIST
          IF(INUM.GT.(IPTS/2.).AND.IDIST.GT.0)XT=A(5,LNUM)*
         +(1.-.5*((IPTS-(INUM-1.))/IPTS*2.)**IDIST)
          IF(IDIST.LE.0.AND.INUM.LE.(IPTS/2.))XT=.5*A(5,LNUM)*
         +EXP(((INUM-1.)/IPTS*2.-1.)**IDIST)
    C
    C
          IF(IDIST.LE.0.AND.INUM.GT.(IPTS/2.))XT=A(5,LNUM)-
         +.5*A(5,LNUM)*EXP(((IPTS-(INUM-1.))/IPTS*2.-1.)**IDIST)
          XXX=XT/A(5,LNUM)
    C
          XRAD(INUM)=2.*3.14159*XT/A(5,LNUM)
          XSOL=XT+XHIGH
          IF(XSOL.LT.0.0)XSOL=XSOL+A(5,LNUM)
          T=TE(XSOL)
          RADIAN=2.*3.14159*XT/A(5,LNUM)
          DO 4 ICOS1=1,IGRAFS
          IF(ITYPE.EQ.2)X(INUM,ICOS1)=EXP(-XXX**2*ICOS1)
          IF(ITYPE.EQ.1)X(INUM,ICOS1)=COS(ICOS1*RADIAN)
    4     CONTINUE
    C     SOL=1./1400.*10.**(A(8,LNUM)-A(9,LNUM)/T)
    C     SOL=A(8,LNUM)*EXP(-A(9,LNUM)/1.987/T)
          SOL=EXP(A(8,LNUM))*EXP(A(9,LNUM)/1.987*(1./773.-
         +1./T))
    3     X(INUM,10)=SOL*1.E+10
    C
    C     LOOP TO CALCULATE COSINES AND DRAW GRAPHS
          CALL NOBRDR
          DO 10 ICOS2=1,IGRAFS
          DO 9 ICOS3=1,ICOS2
          DO 8 INUM4=1,30
          XX(INUM4,ICOS2+1)=X(INUM4,10)
    C      SET UP DEPENDENT AND INDEPENDENT VARIABLES
    8     XX(INUM4,ICOS3)=X(INUM4,ICOS3)
```

```
 9      CONTINUE
        NBR(2)=IPTS
        NBR(3)=IPTS
        NBR(1)=ICOS2+1
 C      CALCULATE COEFFICIENTS OF COSINES
        CALL BECOVM(XX,35,NBR,TEMP,XYBAR,VCV,IER)
        CALL RLMUL(VCV,XYBAR,NBR(3),ICOS2,.05,ANOVA,B,10,VARB,IER)
        DO 5 INUMM=1,30
        YDR(INUMM)=B(ICOS2+1,1)
 C
 C      CALCULATE THE FITTED COSINE AND GRAPH IT
        DO 5 ICC=1,ICOS2
 5      YDR(INUMM)=YDR(INUMM)+B(ICC,1)*XALL(INUMM,ICC)
        CALL TITLE("COSINE WAVES$",100,"RADIANS$",100,1H ,1,6.,8.)
        CALL DFRAME
        CALL GRAF(-.75,.75,6.25,0.,1.,5.)
        CALL MESSAG("NO. OF COSINES IS $",100,2.,7.6.)
        CALL INTNO(ICOS2,"ABUT","ABUT")
        CALL MESSAG("PHASE ANGLE (RADIANS)$",100,2.,7.4)
        CALL REALNO(SHIFTR,2,"ABUT","ABUT")
        CALL MESSAG("OFFSET POSITION (CM)$",100,2.,7.2)
        CALL REALNO(XHIGH,0,"ABUT","ABUT")
        CALL MESSAG("NO. OF POINTS $",100,2.,7.)
        CALL INTNO(IPTS,"ABUT","ABUT")
        CALL MESSAG("DISTRIBUTION TYPE $",100,2.,6.8)
        CALL INTNO(IDIST,"ABUT","ABUT")
        CALL MESSAG("BASE LEVEL & STD. DEV.$",100,2.,6.6)
        CALL REALNO(B(ICOS2+1,1),2,2.,6.4)
        CALL REALNO(B(ICOS2+1,4),3,"ABUT","ABUT")
        DO 6  ISCALE=1,ICOS2
        SCALEA(ISCALE)=B(ISCALE,4)/B(ICOS2+1,1)
 6      SCALE(ISCALE)=B(ISCALE,1)/B(ICOS2+1,1)
        CALL MESSAG("AMPS. & SDEVS. REL TO BASE:$",100,2.,6.2)
        CALL REALNO(SCALE(1),2,2.,6.)
        CALL REALNO(SCALEA(1),3,"ABUT","ABUT")
        IF(ICOS2.GT.1)CALL REALNO(SCALE(2),2,2.,5.80)
        IF(ICOS2.GT.1)CALL REALNO(SCALEA(2),3,"ABUT","ABUT")
        IF(ICOS2.GT.2)CALL REALNO(SCALE(3),2,"ABUT","ABUT")
        IF(ICOS2.GT.2)CALL REALNO(SCALEA(3),3,"ABUT","ABUT")
        IF(ICOS2.GT.3)CALL REALNO(SCALE(4),2,2.,5.6)
        IF(ICOS2.GT.3)CALL REALNU(SCALEA(4),3,"ABUT","ABUT")
        IF(ICOS2.GT.4)CALL REALNO(SCALE(5),2,"ABUT","ABUT")
        IF(ICOS2.GT.4)CALL REALNO(SCALEA(5),3,"ABUT","ABUT")
        IF(ICOS2.GT.5)CALL REALNO(SCALE(6),2,2.,5.4)
        IF(ICOS2.GT.5)CALL REALNO(SCALEA(6),3,"ABUT","ABUT")
        IF(ICOS2.GT.6)CALL REALNO(SCALE(7),2,"ABUT","ABUT")
        IF(ICOS2.GT.6)CALL REALNO(SCALEA(7),3,"ABUT","ABUT")
        IF(ICOS2.GT.7)CALL REALNO(SCALE(8),2,2.,5.2)
        IF(ICOS2.GT.7)CALL REALNO(SCALEA(8),3,"ABUT","ABUT")
        IF(ICOS2.GT.8)CALL REALNO(SCALE(9),2,"ABUT","ABUT")
        IF(ICOS2.GT.8)CALL REALNO(SCALEA(9),3,"ABUT","ABUT")
        CALL MESSAG(" DF:REG,RES,CTOT $",100,2.,5.0)
        CALL REALNO(ANOVA(1),0,"ABUT","ABUT")
        CALL REALNO(ANOVA(2),0,"ABUT","ABUT")
        CALL REALNO(ANOVA(3),0,"ABUT","ABUT")
        CALL MESSAG("SSQ:REG,RES,CTOT $",100,2.,4.8)
        CALL REALNO(ANOVA(4),2,"ABUT","ABUT")
        CALL REALNO(ANOVA(5),2,"ABUT","ABUT")
        CALL REALNO(ANOVA(6),2,"ABUT","ABUT")
        CALL CURVE(XEXP,YEXP,30,0)
```

```
         CALL DASH
         CALL SCLPIC(.1)
           CALL CURVE(XEXP,YDR,30,0)
         CALL RESET("DASH")
         CALL CURVE(XRAD,X(1,10),IPTS,-1)
   10    CALL ENDPL(0)
         GO TO 1000
         END
C        ********************:NEED SUBROUTINE   FUNCTION TE(X)
C**********************  FROM PROGRAM METAL
C*******************  NEED SUBROUTINE RLMUL FROM PROGRAM LOOPLS
C
C
C
```

```
C      LATEST REVISION APRIL 28, 1980
C      DON BAUER UW MADISON WISCONSIN 53706
C      CHEM ENGRG/NUCL ENGRG DEPT
C      LITHIUM LOOP EXPERIMENT
C
C
       PROGRAM SOLGRAPH(OUTSOL,
      +TAPE6=OUTSOL,OUTPUT,TAPE9=OUTPUT,PRINT)
       CALL CHANGE(4R+SOL)
       CALL KEEP80(1,3)
       CALL GFSIZE(3,3000000B)
90803  CALL FR80ID(8HSOLGRAPH,1,2,1)
90804  CALL PLTS
       DIMENSION XL(16), X1(50),S(50), X(2),Y(2),IPAK(170)
       DIMENSION BESKCX(4),BESKCY(4),BESKPX(4),BESKPY(4)
       DIMENSION XMINSH(2),YMINSH(2), BYCHVX(4),BYCHVY(4)
       DIMENSION XLEAV(16),YLEAV(16),UWX(8),UWY(8)
       DATA BESKCX/900.,800.,600.,400./,BESKCY/323.,250.,70.,30./
       DATA BESKPX/1000.,800.,600.,400./,BESKPY/80.,60.,50.,40./
       DATA BYCHVX/1200.,1000.,900.,0./,BYCHVY/350.,200.,100.,0./
       DATA XMINSH/760.,662./,YMINSH/85.,27./
       DATA XLEAV/.838,.845,.85,.852,.858,3*.867,.87,.881,
      +.89,.896,.896,.93,.96,1.073/
       DATA YLEAV/80.,120.,120.,100.,80.,100.,90.,75.,80.,65.,
      +72.,75.,60.,75.,40.,20./
       DATA SANDX/760./,SANDY/120./, UWX/450.,7*500./
       DATA UWY/30.,5.,10.,2.35,3.3,2.68,4.8,3.1/
       CALL LINES("BESKOR.,REGULAR$",IPAK,1)
       CALL LINES("BESKOR.,PURE LI$",IPAK,2)
       CALL LINES("BYCHOV$",IPAK,3)
       CALL LINES("SAND$",IPAK,6)
       CALL LINES("MINUSHKIN$",IPAK,5)
       CALL LINES("LEAVENWORTH$",IPAK,4)
       CALL LINES("THIS WORK, DC ARC$",IPAK,7)
       CALL LINES("THIS WORK, ICP$",IPAK,8)
       CALL NOBRDR
       CALL TITLE("IRON-LITHIUM SYSTEM$",100,"WEIGHT PPM IRON$",
      +100,"TEMPERATURE, CENTIGRADE$",100,6.,8.)
       CALL DFRAME
       CALL GRAF(0.,50.,400.,400.,100.,1200.)
       DO 17 I=1,16
17     XL(I)=1000./XLEAV(I)-273.
       CALL CURVE(BESKCY,BESKCX,4,-1)
       CALL CURVE(BESKPY,BESKPX,4,-1)
       CALL CURVE(BYCHVY,BYCHVX,3,-1)
       CALL CURVE(YLEAV,XL,16,-1)
       CALL CURVE(YMINSH,XMINSH,2,-1)
       CALL CURVE(SANDY,SANDX,1,-1)
       CALL CURVE(UWY,UWX,3,-1)
       CALL CURVE(UWY(4),UWX(4),5,-1)
       CALL LEGEND(IPAK,8,3.,2.)
       CALL ENDPL(0)
       CALL NOBRDR
       CALL TITLE("IRON IN LITHIUM$",100,"10000/T(K)$",100,
      +"IRON IN LITHIUM, WEIGHT PPM$",100,7.,6.)
       CALL DFRAME
       CALL YLOG(6.25,1.25,1.,2.)
       DO 1 I=1,4
       BESKCX(I)=10000./(BESKCX(I)+273.)
       BESKPX(I)=10000./(BESKPX(I)+273.)
```

```
1       BYCHVX(I)=10000./(BYCHVX(I)+273.)
        DO 2 I=1,8
2       UWX(I)=10000./(UWX(I)+273.)
        DO 3 I=1,16
3       XLEAV(I)=10.*XLEAV(I)
        CALL CURVE(BESKCX,BESKCY,4,-1)
        CALL CURVE(BESKPX,BESKPY,4,-1)
        CALL CURVE(BYCHVX,BYCHVY,3,-1)
        CALL CURVE(XLEAV,YLEAV,16,-1)
        XMINSH(1)=10000./(XMINSH(1)+273.)
        XMINSH(2)=10000./(XMINSH(2)+273.)
        CALL CURVE(XMINSH,YMINSH,2,-1)
        SANDX=10000./(SANDX+273.)
        CALL CURVE(SANDX,SANDY,1,-1)
        CALL CURVE(UWX,UWY,3,-1)
        CALL CURVE(UWX(4),UWY(4),5,-1)
        CALL LEGEND(IPAK,8,.5,.5)
        XLEAV(1)=8.2
        XLEAV(2)=6.8
        CALL DASH
C       56/7 CONVERTS FROM ATOM FRACTION TO WEIGHT FRACTION
C       .0049 CONVERTS .49 ATOM% TO ATOM FRACTION
C       10**6 CONVERTS TO PPM
        YLEAV(2)=1.E6*56./7.*.00494*10.**(-.31*XLEAV(2))
        YLEAV(1)=1.E6*56./7.*.00494*10.**(-.31*XLEAV(1))
        CALL CURVE(XLEAV,YLEAV,2,0)
        CALL RESET("DASH")
        XLEAV(2)=11.
        YLEAV(2)=1.E6*56./7.*.00494*10.**(-.31*XLEAV(2))
        CALL CURVE(XLEAV,YLEAV,2,0)
        CALL DASH
        XLEAV(1)=13.8
        YLEAV(1)=1.E6*56./7.*.00494*10.**(-.31*XLEAV(1))
        CALL CURVE(XLEAV,YLEAV,2,0)
        CALL RESET("DASH")
        BESKCX(2)=BESKCX(3)
        BESKPX(2)=BESKPX(3)
        BESKCY(2)=BESKCY(3)
        BESKPY(2)=BESKPY(3)
        CALL DOT
        CALL CURVE(BESKPX,BESKPY,2,0)
        CALL CURVE(BESKCX,BESKCY,2,0)
        CALL RESET("DOT")
        DO 20 I=1,50
        T=500.+I*10.
        S(I)=.178*T-17.5
20      X1(I)=10000./(T+273.)
        CALL CHNDOT
        CALL CURVE(X1,S,50,0)
        CALL RESET("CHNDOT")
        DO 5 I=800,2000,100
        IF(I.EQ.1300.OR.I.EQ.1500.OR.I.EQ.1700.OR.I.EQ.
       +1900.OR.I.EQ.1100.OR.I.EQ.1800)GO TO 5
        XSPOT=10000./((I-32.)/1.8+273.)
        XS=XPOSN(XSPOT,500.)
        YS=YPOSN(XSPOT,500.)
        X(1)=XSPOT
        X(2)=XSPOT
        Y(1)=500.
        Y(2)=400.
```

```
      CALL CURVE(X,Y,2,0)
      CALL INTNO(I,XS-.2,YS)
116      CALL MESSAG("F",1,"ABUT","ABUT")
5     CONTINUE
      DO 6 I=400,1200,100
      IF(I.EQ.1100.OR.I.EQ.900)GO TO  6
      J=I
      RIV=10000./(J+273.)
      XS=XPOSN(RIV,800.)
      YS=YPOSN(RIV,800.)
      X(1)=RIV
      X(2)=RIV
      Y(1)=700.
      Y(2)=800.
      CALL CURVE(X,Y,2,0)
      CALL INTNO(J,XS-.4,YS)
130      CALL MESSAG("C",1,"ABUT","ABUT")
6     CONTINUE
      CALL ENDPL(0)
      CALL DONEPL
      CALL PLOTE
      CALL QUIT(1)
      END
```

APPENDIX S. PROGRAM STFIT

Fit j-factor Curve in Transition Region

(Uses routines from graphics package DISSPLA)

PROGRAM BYPASS

Determine amount of lithium which
may be bypassing the coupons.

Curve Fitting the Transition Region of j factor Chart

The Sieder-Tate j-factor chart has log[Re] as the abscissa and log[Nu Re^{-1} $Pr^{-1/3}$) as the ordinate.

The transition region curves appear to be exponential rises from the (extrapolated) laminar lines toward the asymptote (extrapolated to low Re) of the turbulent region.

The transition curves, denoted j', can be expressed in terms of the laminar and turbulent j factors, denoted j_l and j_t, respectively, and the Reynolds numbers Re and Re', where Re' is a constant.

The transition curves, then, are fit by

$$\ln[j'] = \ln[j_t] - (\ln[j_t] - \ln[j_l]) \exp\left(\frac{\ln[Re] - \ln[2100]}{\ln[Re'] - \ln[2100]} \right)$$

By trial and error graphing, Re' was adjusted to fit the Sieder and Tate chart in the transition region. The best value of Re' is about 3300.

The above expression for ln[j'] reduces to

$$\ln[j'] = \ln[j_t] - \ln\left[\frac{j_t}{j_l}\right] \exp\left(\frac{\ln[2100]}{\ln[3300/2100]}\right) \exp\left(\frac{-\ln[Re]}{\ln[3300/2100]}\right)$$

$$\text{"} \quad = \quad \text{"} \qquad \text{"} \qquad K \qquad \exp\left(-\frac{\ln[Re]}{B}\right)$$

where $K = 22.41 \times 10^6$ and B^{-1} is 2.2125

Therefore,

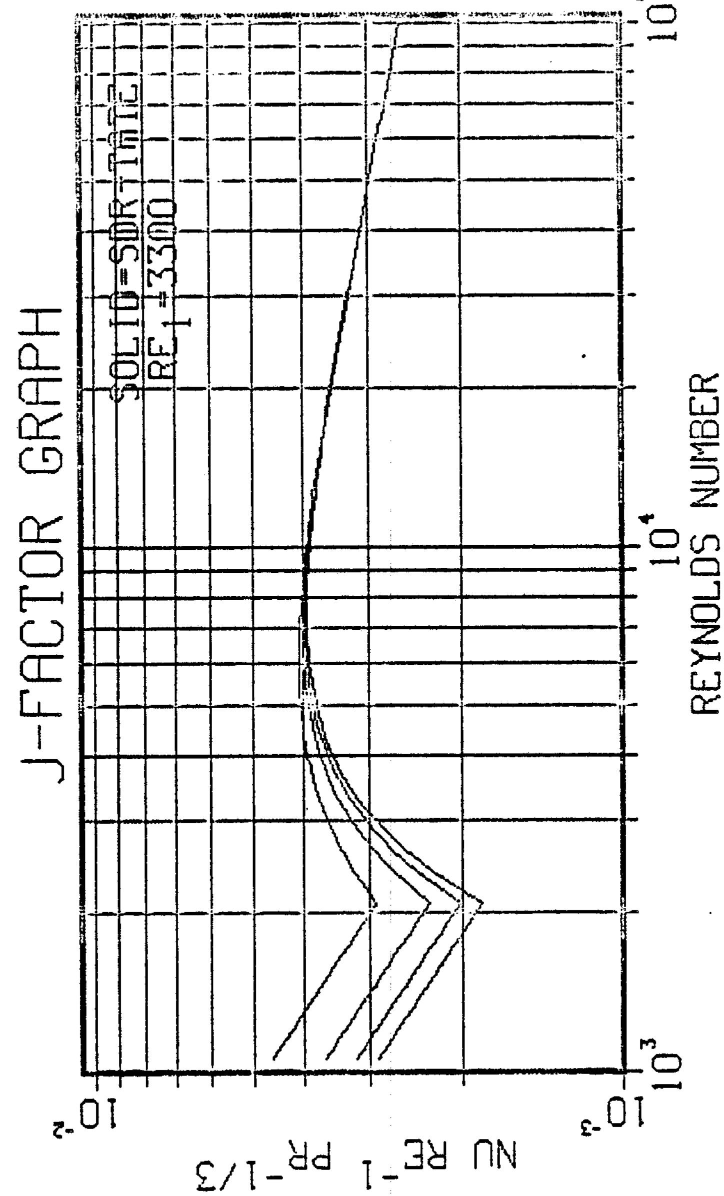
$$\ln[j'] = \ln[j_t] - \ln\left[\frac{j_t}{j_l}\right] K \, Re^{-(1/B)}$$

$$j' = \frac{j_t}{\left[\frac{j_t}{j_l}\right]^{K/Re^{(1/B)}}}$$

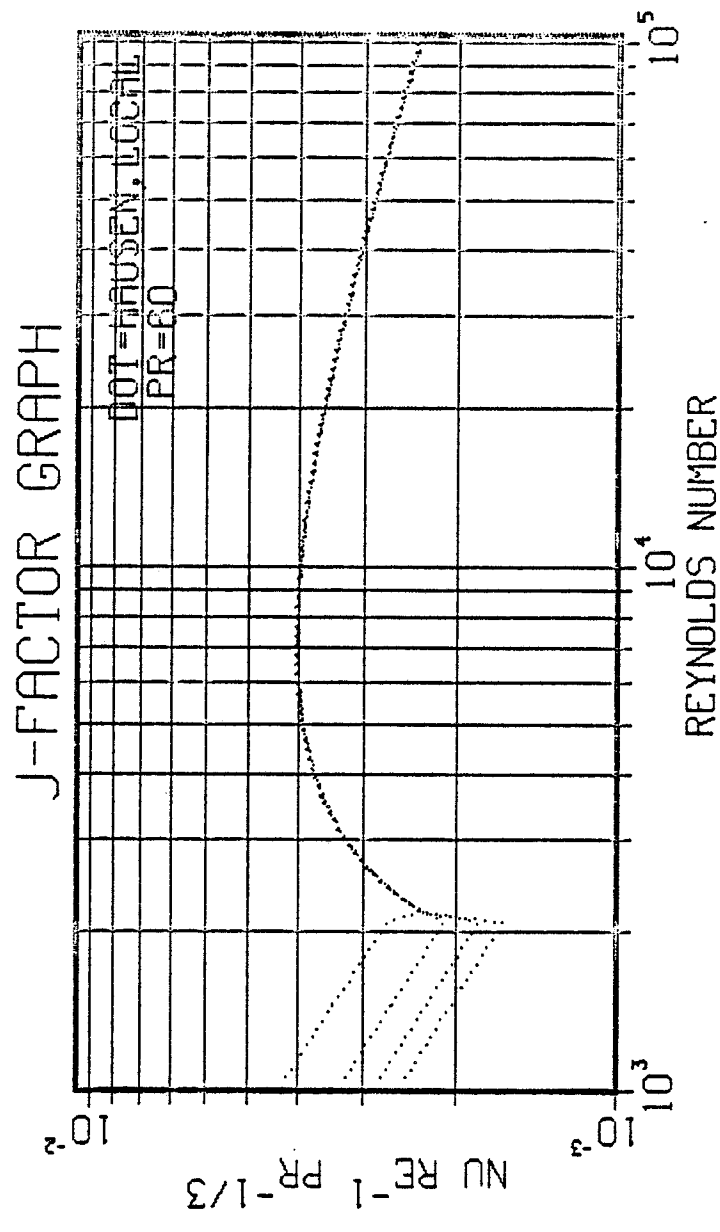
```
C     LATEST REVISION MARCH 11, 1980
      PROGRAM STFIT(STDATA,TAPE5=STDATA,OUTFIL,TAPE6=OUTFIL,
     +OUTPUT,TAPE9=OUTPUT,PRINT)
C     PROGRAM TO FIT SIEDER TATE EQUATION ABOVE REYNOLDS NO OF 2100
C     WRITTEN BY DONALD BAUER
C     UNIVERSITY OF WISCONSIN
C     SEPTEMBER 29, 1979
C
      CALL CHANGE(4R+STF)
      CALL KEEP80(1,3)
      CALL FR80ID("EXAMPLE",1,2,1)
      CALL PLTS
      DIMENSION XD(100),Y1(100),X1(100),Y2(100),Y3(100)
      AL26=ALOG(.026)
C     USE 1.62 INSTEAD OF 1.86************************************
      AL186=ALOG(1.86)
 2    READ (5,1)I1,I2,I3,IPR,IF1,IF2,IF3
      PRNDTL=IPR
C     ****************************************************************
C     ****************************************************************
C     FROM=*-500TO====00008Y====0100PRNDTL=060EQUATS=100
C     FROM=*-300TO====0000BY====0100PRNDTL=060EQUATS=100
C     FROM=*-500TO====00208Y====0100PRNDTL=060EQUATS=100
C     FROM=*-300TO====00208Y====0100PRNDTL=060EQUATS=100
C     FROM==3300TO====3300BY====0100PRNDTL=060EQUATS=100
C     FROM==3300TO====3300BY====0100PRNDTL=060EQUATS=110
C     000000000
C     OPTIMIZE THE "TIME-CONSTANT" OF THE REYNOLDS NUMBER EFFECT
C     I1 IS STARTING REYNOLDS,I2 FINISH, I3 INTERVAL OF TEST GRAPHING
C        OR--IF I1 IS NEGATIVE, IT GIVES THE LENGTH REYNOLDS NUMBER
C        FOR TRANSITION TO TURBULENT FLOW, (IN THOUSANDS) AND THE I2
C        IS THE L/D VALUE AT THE START OF THE HEATING SECTION
C     TOTAL L/D VALUES OF 60,120,180 AND 240 ARE PLOTTED
C     IPR IS PRANDTL NUMBER
C     ****************************************************************
C     ****************************************************************
      IF(I1.EQ.0)GO TO 40
      IF(I1.LT.0)GO TO 150
 1    FORMAT(3(6X,I4),7X,I3,7X,3I1)
      PRNDTL=IPR
      IF(IF1.NE.1) I2=I1
C
C     VARY THE REYNOLDS NUMBER "HAFREN" TO FIND BEST EXPONENTIAL FIT
      DO 30 K=I1,I2,I3
      YDIS=2.5
      HAFREN=K
      B=-ALOG(2100.)+ALOG(HAFREN)
      CALL NOBRDR
      CALL MIXALF("INSTRUCTION")
      CALL TITLE("J-FACTOR GRAPH$",100,"REYNOLDS NUMBER$",100,
     +"NU RE(E)-1(EX) PR(E)-1/3(EX)$",100,5.5,2.8)
      IF(IF1.EQ.1)CALL MESSAG("SOLID=SDR-TATE$",100,3.0,YDIS)
      IF(IF1.EQ.1)YDIS=YDIS-.2
      IF(IF1.EQ.1)CALL MESSAG(" RE(L)1(LX)=$",100,3.0,YDIS)
      IF(IF1.EQ.1)CALL INTNO(K,"ABUT","ABUT")
      IF(IF1.EQ.1)YDIS=YDIS-.3
      IF(IF2.EQ.1)CALL MESSAG("DASH=HAUSEN,MEAN$",100,3.0,YDIS)
      IF(IF2.EQ.1)YDIS=YDIS-.2
      IF(IF3.EQ.1)CALL MESSAG("DOT=HAUSEN,LOCAL$",100,3.0,YDIS)
      IF(IF3.EQ.1)YDIS=YDIS-.2
```

```
      IF(IF2.EQ.1.OR.IF3.EQ.1)CALL MESSAG(" PR=$",100,3.0,YDIS)
      IF(IF2.EQ.1.OR.IF3.EQ.1)CALL INTNO(IPR,"ABUT","ABUT")
      CALL LOGLOG(1000.,2.73,.001,2.73)
      CALL GRID(1,1)
      CALL DFRAME
      AK=ALOG(2100.)
C     VARY THE L/D FROM 240 TO 60
      DO 20 J=240,60,-60
      Y=-ALOG(J*1.)
      XOVRD=J
      DO 10 I=1,100
      TENLOG=3.+2./100.*I
      REYN=10**(TENLOG)
      X=ALOG(REYN)
C
C
C     GET LOGARITHMS OF J FACTORS, TURBULENT AND LAMINAR
      XTURB=AL26-.2*X
      XLAM=AL186-.666*X+.333*Y
      XD(I)=EXP((AK-X)/8)
      X1(I)=XLAM*XD(I)+XTURB*(1.-XD(I))
      XLAM1=(3.65+.0668*REYN*PRNDTL/XOVRD/(1.+.04*
     +(REYN*PRNDTL/XOVRD)**.6666))/REYN/PRNDTL**.3333
      XTMEAN=0.116*(REYN**.6666-125.)*(1.+XOVRD**-.6666)/REYN
      XTLOC=0.116*(REYN**.6666-125.)*(1.+.3333*XOVRD**-.6666)
     +/REYN
C
C     THESE ARE THE  HAUSEN EQUATIONS FOR MEAN AND LOCAL TURB ENTRY
      IF(REYN.GT.2100.)Y1(I)=EXP(X1(I))
      IF(REYN.GE.2100.)Y2(I)=(XTMEAN)
      IF(REYN.GE.2100.)Y3(I)=(XTLOC)
      IF(REYN.LE.2100.)Y1(I)=EXP(XLAM)
      IF(REYN.LT.2100.)Y2(I)=(XLAM1)
      IF(REYN.LT.2100.)Y3(I)=(XLAM1)
      X1(I)=EXP(X)
 10   CONTINUE
C
      IF(IF1.EQ.1)CALL CURVE(X1,Y1,100,0)
      CALL CHNDSH
      IF(IF2.EQ.1)CALL CURVE(X1,Y2,100,0)
      CALL DOT
      IF(IF3.EQ.1)CALL CURVE(X1,Y3,100,0)
      CALL RESET("DOT")
 20   CONTINUE
 30   CALL ENDPL(0)
      GO TO 2
 150  CALL NOBRDR
      CALL MIXALF("INSTRUCTION")
      CALL TITLE("J-FACTOR GRAPH$",100,"REYNOLDS NUMBER$",100,
     +"NU RE(E)-1(EX) PR(E)-1/3(EX)$",100,5.5,2.8)
      CALL LOGLOG(1000.,2.73,.001,2.73)
      CALL GRID(1,1)
      CALL DFRAME
      CALL MESSAG("L/D(L)0(LX)=$",100,3.0,2.2)
      CALL INTNO(I2,"ABUT","ABUT")
      IF(IF1.EQ.1)CALL MESSAG("S-T LAM. EQN.$",100,3.,1.9)
      IF(IF1.NE.1.AND.IF2.EQ.1)CALL MESSAG("HAUSEN LAM. EQN.$",100,
     +3.,1.9)
      IF(IF1.NE.1.AND.IF2.EQ.1)CALL MESSAG("PR=$",100,3.,1.6)
      IF(IF1.NE.1.AND.IF2.EQ.1)CALL INTNO(IPR,"ABUT","ABUT")
```

```
      CALL MESSAG("AVERAGE J FACTOR WHEN TRANSITION $",100,1.,.7)
      CALL MESSAG("FROM LAMINAR TO TURBULENT OCCURS$",100,1.,.5)
      CALL MESSAG("PARTWAY INTO TUBE AT RE(L)X(LX)=$",100,1.,.3)
      REX=IABS(I1)*1000.
      REXX=REX/1.E5
      CALL REALNO(REXX,1,"ABUT","ABUT")
      CALL MESSAG("X10(E)5(EX)$",100,"ABUT","ABUT")
      DO 200 LD=60,240,60
      RLD=LD
      DO 190 IRE=1,100
      REALI2=I2
      TENLOG=3.+2./100.*IRE
      REYN=10**TENLOG
      X1(IRE)=REYN
      TRANLD=REX/REYN
      IF(TRANLD.GT.LD.OR.REYN.LT.2100.)TRANLD=LD
      IF(IF1.EQ.1)
     +A=1.86*REYN**(-2./3.)*(TRANLD**(2./3.)-REALI2**(2./3.))
      IF(IF2.EQ.1)A=TRANLD*
     +(3.65+.0668*REYN*PRNDTL/TRANLD/(1.+.04*
     +(REYN*PRNDTL/TRANLD)**.6666))/REYN/PRNDTL**.3333
      IF(I2.GT.0.AND.IF2.EQ.1)A=A-I2*
     +(3.65+.0668*REYN*PRNDTL/REALI2/(1.+.04*
     +(REYN*PRNDTL/REALI2)**.6666))/REYN/PRNDTL**.3333
      BB=.026*REYN**(-.2)*(RLD-TRANLD)
      Y1(IRE)=(A+BB)/(RLD-REALI2)
  190 IF(Y1(IRE).LE..001)Y1(IRE)=1.E-3
      CALL CURVE(X1,Y1,100,0)
  200 CONTINUE
      CALL ENDPL(0)
      GO TO 2
   40 CALL RESET("MIXALF")
      CALL DONEPL
      CALL QUIT(1)
      END
```



J-FACTOR GRAPH
RE 1 =3300
REYNOLDS NUMBER
NU RE⁻¹ PR⁻¹/³
10^3
10^4
10^5
10^-2
10^-3

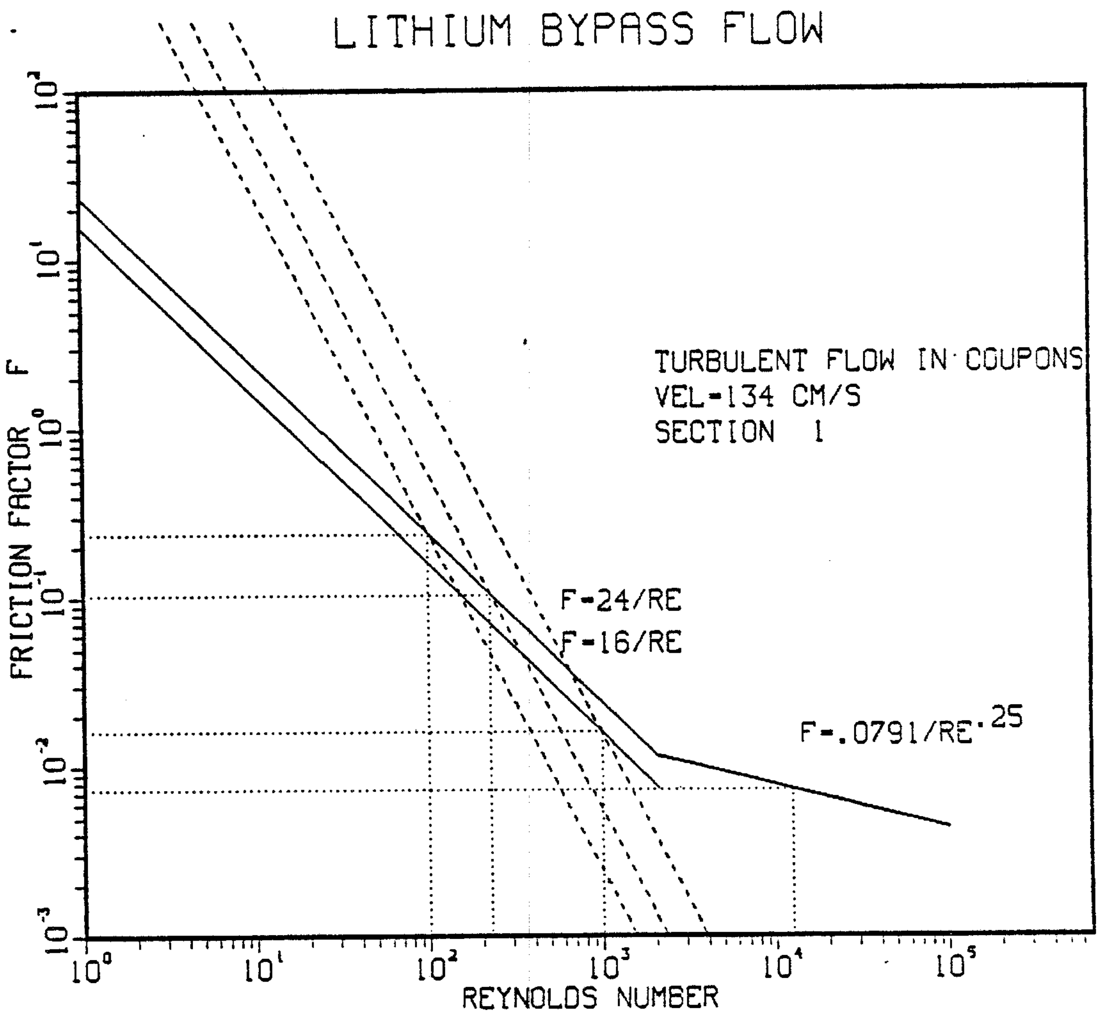

J-FACTOR GRAPH
DOT=HAUSEN, LOCAL
PR=60
REYNOLDS NUMBER
10^3
10^4
10^5
NU RE^-1 PR^-1/3
10^-3
10^-2

```
C     LATEST REVISION MAY 14, 1980
      PROGRAM BYPASS(INBY,TAPE5=INBY,OUTBY,TAPE6=OUTBY,
     +OUTPUT,TAPE9=OUTPUT)
C     WRITTEN BY DON BAUER   UW MADISON WISCONSIN 5370
C     CHEM ENGRG / NUCL ENGRG DEPTS
C     LITHIUM LOOP EXPERIMENT
C     PROGRAM TO FIND BYPASS FLOWS IN COUPON ZONE
C
      CALL CHANGE(4R+BYP)
      CALL KEEP80(1,3)
      CALL FR80ID("PARALLEL BYPASS PATHS",1,3)
      CALL PLTS
C
      DIMENSION DIAM(5),AREA(5),AREAF(5),RESQRF(5),FSTAR(5),
     +RESTAR(5),VEL(5,4),RE(5,4),Q(5,4),FLUX(5,4),AMT(5,4),
     +TAMT(5,4),APSAT(5,4),X(40),Y(40),F(5,4),
     +FACTR2(5),XX(4),DID(2,5)
      DATA DID/"COUP",". ID","COUP",". OD","STRG",". OD","CUT ","LAM.",
     +"CUT ","TRB."/
      DATA FACTR2/1.,.5,0.,.5,.5/
      DATA PI/3.14159/,RESTAR/3*1000.,100.,10000./
      READ(5,501)(VEL(1,I),I=1,4),TC,PREEXP,ALEN
501   FORMAT(8F5.0)
C     SET DIAMETERS IN ARRAY DIAM
      DIAM(1)=.2425*2.54
      DIAM(2)=(.333-.3125)*2.54
      DIAM(3)=(.527-.5)*2.54
      DLEN=(.527-.3125)/2.*2.54
      DWID=0.1
C     CUT IS 1 MM WIDE
      DIAM(4)=4.*(DWID*DLEN)/(2.*(DWID+DLEN))
      DIAM(5)=DIAM(4)
      AREA(1)=PI/4.*DIAM(1)**2
      AREA(2)=PI*.333*DIAM(2)/2.*2.54
      AREA(3)=PI*.527*2.54*DIAM(3)/2.
      AREA(4)=DWID*DLEN
      AREA(5)=DWID*DLEN
      AREAF(1)=PI*DIAM(1)*ALEN
      AREAF(2)=PI*2.*.3125*2.54*ALEN
      AREAF(3)=PI*2.*.5*2.54*ALEN
      AREAF(4)=(DWID*DLEN)*2.*ALEN
      AREAF(5)=AREAF(4)
      FSTAR(1)=16./RESTAR(1)
      FSTAR(2)=24./RESTAR(2)
      FSTAR(3)=24./RESTAR(3)
      FSTAR(4)=16./RESTAR(4)
      FSTAR(5)=.0791/RESTAR(5)**.25
      T=TC+273.
      SOL=EXP(PREEXP)*EXP(14200./1.987*(1./773.-1/T))
      DC=SOL/2.
      DENS=.515-.000101*(TC-200.)
      VISC=10.**(1.4936-.7368*ALOG10(T)+109.95/T)/100.
      DIFF=1.38*T/VISC/6./PI/1.25*10.**(-8)
      SCHM=VISC/DENS/DIFF
C     CALCULATE FOR EACH TEST SECTION:
C        THE REYNOLDS NUMBER * SQRT(F), WHICH IS A CONSTANT
C
      DO 600 LAMTUR=1,2
      WRITE(6,499)
499   FORMAT("1",///////)
```

```
      DO 505 I=1,4
      RE(1,I)=DIAM(1)*VEL(1,I)*DENS/VISC
      IF(LAMTUR.EQ.1)F(1,I)=16./RE(1,I)
      IF(LAMTUR.EQ.2)F(1,I)=.0791/RE(1,I)**.25
      RESQR=RE(1,I)*SQRT(F(1,I))
505   XX(I)=RESQR/DIAM(1)**1.5
C     XX IS CONSTANT IN ALL FLOW PATHS IN A GIVEN TEST SECTION
      DO 550 I=1,4
      RESQRF(1)=XX(I)*DIAM(1)**1.5
      RESQRF(2)=XX(I)*(DIAM(2)*1.5)**1.5
      RESQRF(3)=XX(I)*(DIAM(3)*1.5)**1.5
      RESQRF(4)=XX(I)*DIAM(4)**1.5
      RESQRF(5)=XX(I)*DIAM(5)**1.5
      WRITE(6,510)I,TC,VEL(1,I),ALEN,SOL
510   FORMAT(/,17X,"TEST",
     +" SECTION #",I1,", TEMP ",F4.0,"C, VEL ",F5.1,"CM/S,",
     +/,17X," LENGTH ",F4.0,"CM, SOL ",E10.2,"GMOL/CC,",/,
     +17X,"ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.")
      IF(LAMTUR.EQ.1)WRITE(6,511)
      IF(LAMTUR.EQ.2)WRITE(6,512)
511   FORMAT(17X,"ASSUME LAMINAR FLOW INSIDE COUPONS.")
512   FORMAT(17X,"ASSUME TURBULENT FLOW INSIDE COUPONS.")
      DO 540 J=1,5
      IF(J.EQ.2.OR.J.EQ.3)RE(J,I)=RESQRF(J)**2./24.
      IF(J.EQ.2.OR.J.EQ.3)F(J,I)=24./RE(J,I)
      IF(J.EQ.4)RE(J,I)=RESQRF(J)**2./16.
      IF(J.EQ.4)F(4,I)=16./RE(4,I)
      IF(J.EQ.5)RE(5,I)=RESQRF(J)**(8./7.)/.0791**(4./7.)
      IF(J.EQ.5)F(5,I)=.0791/RE(5,I)**.25
      VEL(J,I)=RE(J,I)/DIAM(J)/DENS*VISC
513   Q(J,I)=VEL(J,I)*AREA(J)
      AMUL=4.*1.62*(3.14159/4.)**(2./3.)
      APSAT(J,I)=1.-EXP(-AMUL*(DIFF*ALEN/Q(J,I))**.6666)
      EXX=.104*RE(1,I)**(-.2)*SCHM**(-.6666)
     +*ALEN/DIAM(1)
      IF(LAMTUR.EQ.2)APSAT(1,I)=1.-EXP(-EXX)
      TAMT(J,I)=Q(J,I)*DC*APSAT(J,I)
      AMT(J,I)=TAMT(J,I)*FACTR2(J)
      FLUX(J,I)=TAMT(J,I)/AREAF(J)
540   CONTINUE
      QSUM=Q(1,I)+Q(2,I)+Q(3,I)
      FSUM=AMT(1,I)+AMT(2,I)
      IF(RE(4,I).LE.2100.)QSUM=QSUM+Q(4,I)
      IF(RE(4,I).LE.2100.)FSUM=FSUM+AMT(4,I)
      IF(RE(5,I).GT.2100.AND.RE(4,I).GT.2100)QSUM=QSUM+Q(5,I)
      IF(RE(5,I).GT.2100.AND.RE(4,I).GT.2100)FSUM=FSUM+AMT(5,I)
      IF(RE(5,I).GT.2100.AND.RE(4,I).LE.2100)WRITE(6,543)I
      IF(RE(5,I).LE.2100.AND.RE(4,I).GT.2100)WRITE(6,543)I
543   FORMAT(17X,"***INCONSISTENT REYNOLDS NUMBERS IN STRINGER CUT",
     +", SECTION #",I1)
      QR=Q(1,I)/QSUM
      FR=AMT(1,I)/FSUM
      WRITE(6,541)QSUM,QR,FR
541   FORMAT(
     +/,17X,"TOTAL FLOW=",F6.3,"CC/S, ID FLOW/TOTAL FLOW=",
     +F6.3,",    ID MASS LOSS/TOTAL COUPON LOSS=",F6.3,/,
     +17X,"PATH        RESQRF        F          RE       VEL",
     +"       CC/S     %SATN    TTL- GMOL COUPONS  GMOL/CM2/S")
      DO 545 J=1,5
545   WRITE(6,542)DID(1,J),DID(2,J),RESQRF(J),F(J,I),RE(J,I),VEL(J,I),
```

```
     +Q(J,I),APSAT(J,I),TAMT(J,I),AMT(J,I),FLUX(J,I)
542   FORMAT(17X,2A4,3E10.2,F6.1,5E10.2)
      CALL NOBRDR
      CALL TITLE("LITHIUM BYPASS FLOW$",100,
     +"REYNOLDS NUMBER$",100,"FRICTION FACTOR   F$",100,7.,6.)
      CALL DFRAME
      FRICLO=.001
      RELOW=1.
      CALL LOGLOG(RELOW,1.2,FRICLO,1.2)
      CALL DASH
      DO 546 J=2,5
      ALOGF=2.*ALOG(RE(J,I))-2.*ALOG(RELOW)+ALOG(F(J,I))
      ALOGR=ALOG(RE(J,I))+.5*ALOG(F(J,I))-.5*ALOG(FRICLO)
      X(1)=RELOW
      X(2)=EXP(ALOGR)
      Y(1)=EXP(ALOGF)
      Y(2)=FRICLO
546   CALL CURVE(X,Y,2,0)
C     LINES FOR LAMINAR FLOW DRAWN NOW
C
C
C
      CALL RESET("DASH")
C     NOW DRAW TURBULENT LINE
      CALL MIXALF("INSTRUCTION")
      X(1)=2100.
      X(2)=100000.
      Y(1)=.0791/2100.**.25
      Y(2)=.0791/100000.**.25
      CALL CURVE(X,Y,2,0)
      X1=XPOSN(X(1),Y(1))
      Y1=YPOSN(X(1),Y(1))
      CALL MESSAG("F=.0791/RE(E).25(EX)$",100,(X1+1.),(Y1+.08))
      CALL RESET("INSTRUCTION")
C
C
      DO 548 K=16,24,8
      REYN=RELOW
      X(1)=REYN
      Y(1)=K/REYN
      REYN=600.
      X(2)=REYN
      Y(2)=K/REYN
      REYN=2100.
      X(3)=REYN
      Y(3)=K/REYN
      IF(K.EQ.24)GO TO 548
      X1=XPOSN(X(2),Y(2))
      Y1=YPOSN(X(2),Y(2))
      CALL MESSAG("F=24/RE$",100,X1,(Y1+.6))
      CALL MESSAG("F=16/RE$",100,X1,(Y1+.3))
548   CALL CURVE(X,Y,3,0)
      CALL DOT
      DO 519 J=1,5
      IF(J.EQ.4.AND.RE(4,I).GT.2100.)GO TO 519
      IF(J.EQ.5.AND.RE(5,I).LE.2100.)GO TO 519
C     DRAW DOTTED LINES FROM SOLUTION POINTS TO AXES
      X(1)=RELOW
      Y(1)=F(J,I)
      X(2)=RE(J,I)
```

```
      Y(2)=F(J,I)
      X(3)=RE(J,I)
      Y(3)=FRICLO
      CALL CURVE(X,Y,3,0)
519   CONTINUE
      CALL RESET("DOT")
      CALL MESSAG("VEL=$",100,4.,3.75)
      IV=VEL(1,I)
      CALL INTNO(IV,"ABUT","ABUT")
      CALL MESSAG(" CM/S$",100,"ABUT","ABUT")
      CALL MESSAG("SECTION #$",100,4.,3.5)
      CALL INTNO(I,"ABUT","ABUT")
      IF(LAMTUR.EQ.1)CALL MESSAG("LAMINAR FLOW IN COUPONS$",100,4.,4.)
      IF(LAMTUR.EQ.2)CALL MESSAG("TURBULENT FLOW IN COUPONS$",100,4.,4.)
550   CONTINUE
      CALL ENDPL
600   CONTINUE
      CALL DONEPL
      CALL PLOTE
      CALL QUIT(1)
      END
```


LITHIUM BYPASS FLOW
TURBULENT FLOW IN COUPONS
VEL=134 CM/S
SECTION 1
F=24/RE
F=16/RE
F=.0791/RE.25
FRICTION FACTOR F
REYNOLDS NUMBER
10^0
10^1
10^2
10^3
10^4
10^5
10^-3
10^-2
10^-1
10^0
10^1
10^2

TEST SECTION #1, TEMP 500.C, VEL 135.0CM/S,
LENGTH 50.CM, SOL 3.39E-08GMOL/CC,
ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.
ASSUME LAMINAR FLOW INSIDE COUPONS.

TOTAL FLOW=41.127CC/S, ID FLOW/TOTAL FLOW= 0.978, ID MASS LOSS/TOTAL COUPON LOSS= 0.891

PATH	RESORF	F	RE	VEL	CC/S	%SATN	TTL- GMOL	COUPONS	GMOL/CM2/S
COUP. ID	4.40E+02	1.28E-03	1.25E+04	135.0	4.02E+01	1.71E-02	1.17E-08	1.17E-08	1.21E-10
COUP. OD	2.02E+01	1.41E+00	1.70E+01	2.2	1.50E-01	5.12E-01	1.30E-09	6.51E-10	5.22E-12
STRG. OD	3.05E+01	6.17E-01	3.89E+01	3.9	5.43E-01	2.62E-01	2.41E-09	0.	6.85E-12
CUT LAM.	5.18E+01	9.54E-02	1.68E+02	7.6	2.07E-01	4.39E-01	1.54E-09	7.72E-10	5.66E-10
CUT TRB.	5.18E+01	1.78E-02	3.88E+02	17.6	4.80E-01	2.81E-01	2.29E-09	1.14E-09	8.40E-10

TEST SECTION #2, TEMP 500.C, VEL 95.0CM/S,
LENGTH 50.CM, SOL 3.39E-08GMOL/CC,
ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.
ASSUME LAMINAR FLOW INSIDE COUPONS.

TOTAL FLOW=28.941CC/S, ID FLOW/TOTAL FLOW= 0.978, ID MASS LOSS/TOTAL COUPON LOSS= 0.898

PATH	RESORF	F	RE	VEL	CC/S	%SATN	TTL- GMOL	COUPONS	GMOL/CM2/S
COUP. ID	3.75E+02	1.82E-03	8.81E+03	95.0	2.83E+01	2.16E-02	1.03E-08	1.03E-08	1.07E-10
COUP. OD	1.70E+01	2.00E+00	1.20E+01	1.5	1.06E-01	5.96E-01	1.07E-09	5.34E-10	4.28E-12
STRG. OD	2.56E+01	8.77E-01	2.74E+01	2.6	3.82E-01	3.19E-01	2.07E-09	0.	5.18E-12
CUT LAM.	4.35E+01	1.36E-01	1.10E+02	5.4	1.46E-01	5.18E-01	1.28E-09	6.41E-10	4.71E-10
CUT TRB.	4.35E+01	1.87E-02	3.17E+02	14.4	3.93E-01	3.15E-01	2.09E-09	1.05E-09	7.68E-10

TEST SECTION #3, TEMP 500.C, VEL 65.0CM/S,
LENGTH 50.CM, SOL 3.39E-08GMOL/CC,
ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.
ASSUME LAMINAR FLOW INSIDE COUPONS.

TOTAL FLOW=19.802CC/S, ID FLOW/TOTAL FLOW= 0.978, ID MASS LOSS/TOTAL COUPON LOSS= 0.906

PATH	RESORF	F	RE	VEL	CC/S	%SATN	TTL- GMOL	COUPONS	GMOL/CM2/S
COUP. ID	3.11E+02	2.65E-03	6.03E+03	65.0	1.94E+01	2.77E-02	9.09E-09	9.09E-09	9.40E-11
COUP. OD	1.40E+01	2.93E+00	8.19E+00	1.0	7.23E-02	6.89E-01	8.44E-10	4.22E-10	3.30E-12.
STRG. OD	2.12E+01	1.28E+00	1.87E+01	1.8	2.61E-01	3.91E-01	1.73E-09	0.	4.34E-12
CUT LAM.	3.59E+01	1.90E-01	8.05E+01	3.7	9.99E-02	6.10E-01	1.03E-09	5.16E-10	3.79E-10
CUT TRB.	3.59E+01	1.98E-02	2.56E+02	11.6	3.16E-01	3.54E-01	1.89E-09	9.47E-10	6.95E-10

TEST SECTION #4, TEMP 500.C, VEL 45.0CM/S,
LENGTH 50.CM, SOL 3.39E-08GMOL/CC,
ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.
ASSUME LAMINAR FLOW INSIDE COUPONS.

TOTAL FLOW=13.709CC/S, ID FLOW/TOTAL FLOW= 0.978, ID MASS LOSS/TOTAL COUPON LOSS= 0.916

PATH	RESORF	F	RE	VEL	CC/S	%SATN	TTL- GMOL	COUPONS	GMOL/CM2/S
COUP. ID	2.58E+02	3.83E-03	4.17E+03	45.0	1.34E+01	3.52E-02	8.01E-09	8.01E-09	8.28E-11
COUP. OD	1.17E+01	4.23E+00	5.67E+00	0.7	5.01E-02	7.75E-01	6.57E-10	3.29E-10	2.64E-12
STRG. OD	1.76E+01	1.95E+00	1.30E+01	1.3	1.81E-01	4.69E-01	1.44E-09	0.	3.60E-12
CUT LAM.	2.99E+01	2.86E-01	5.59E+01	2.5	6.92E-02	6.99E-01	8.20E-10	4.10E-10	3.01E-10
CUT TRB.	2.99E+01	2.09E-02	2.07E+02	9.4	2.56E-01	3.95E-01	1.71E-09	8.57E-10	6.29E-10

TEST SECTION #1, TEMP 500.C, VEL 135.0CM/S,
LENGTH 50.CM, SOL 3.39E-08GMOL/CC,
ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.
ASSUME TURBULENT FLOW INSIDE COUPONS.

TOTAL FLOW=45.496CC/S, ID FLOW/TOTAL FLOW= 0.884, ID MASS LOSS/TOTAL COUPON LOSS= 0.953

PATH	RESORF	F	RE	VEL	CC/S	%SATN	TTL- GMOL	COUPONS	GMOL/CM2/S
COUP. ID	1.08E+03	7.48E-03	1.25E+04	135.0	4.02E+01	9.33E-02	6.36E-08	6.36E-08	6.57E-10
COUP. OD	4.89E+01	2.41E-01	9.95E+01	12.7	8.79E-01	1.90E-01	2.95E-09	1.47E-09	1.18E-11
STRG. OD	7.39E+01	1.06E-01	2.27E+02	22.0	3.18E+00	8.95E-02	4.82E-09	0.	1.21E-11
CUT LAM.	1.25E+02	1.63E-02	9.81E+02	44.6	1.21E+00	1.63E-01	3.35E-09	1.68E-09	1.23E-09
CUT TRB.	1.25E+02	1.38E-02	1.06E+03	48.4	1.32E+00	1.55E-01	3.46E-09	1.73E-09	1.27E-09

TEST SECTION #2, TEMP 500.C, VEL 95.0CM/S,
LENGTH 50.CM, SOL 3.39E-08GMOL/CC,
ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.
ASSUME TURBULENT FLOW INSIDE COUPONS.

TOTAL FLOW=31.157CC/S, ID FLOW/TOTAL FLOW= 0.909, ID MASS LOSS/TOTAL COUPON LOSS= 0.951

PATH	RESORF	F	RE	VEL	CC/S	%SATN	TTL- GMOL	COUPONS	GMOL/CM2/S
COUP. ID	7.96E+02	8.16E-03	8.81E+03	95.0	2.83E+01	9.97E-02	4.78E-08	4.78E-08	4.94E-10
COUP. OD	3.59E+01	4.46E-01	5.38E+01	6.9	4.75E-01	2.83E-01	2.28E-09	1.14E-09	9.13E-12
STRG. OD	5.43E+01	1.95E-01	1.23E+02	11.9	1.72E+00	1.32E-01	3.83E-09	0.	9.61E-12
CUT LAM.	9.21E+01	3.02E-02	5.31E+02	24.1	6.56E-01	2.35E-01	2.62E-09	1.31E-09	9.60E-10
CUT TRB.	9.21E+01	1.51E-02	7.49E+02	34.0	9.27E-01	1.92E-01	3.01E-09	1.51E-09	1.11E-09

TEST SECTION #3, TEMP 500.C, VEL 65.0CM/S,
LENGTH 50.CM, SOL 3.39E-08GMOL/CC,
ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.
ASSUME TURBULENT FLOW INSIDE COUPONS.

TOTAL FLOW=20.835CC/S, ID FLOW/TOTAL FLOW= 0.930, ID MASS LOSS/TOTAL COUPON LOSS= 0.951

PATH	RESORF	F	RE	VEL	CC/S	%SATN	TTL- GMOL	COUPONS	GMOL/CM2/S
COUP. ID	5.71E+02	8.98E-03	6.03E+03	65.0	1.94E+01	1.07E-01	3.52E-08	3.52E-08	3.63E-10
COUP. OD	2.58E+01	8.66E-01	2.77E+01	3.5	2.45E-01	4.04E-01	1.67E-09	8.37E-10	6.72E-12
STRG. OD	3.90E+01	3.79E-01	6.33E+01	6.1	8.84E-01	1.97E-01	2.96E-09	0.	7.41E-12
CUT LAM.	6.61E+01	5.86E-02	2.73E+02	12.4	3.38E-01	3.41E-01	1.95E-09	9.77E-10	7.17E-10
CUT TRB.	6.61E+01	1.66E-02	5.13E+02	23.3	6.34E-01	2.40E-01	2.58E-09	1.29E-09	9.47E-10

TEST SECTION #4, TEMP 500.C, VEL 45.0CM/S,
LENGTH 50.CM, SOL 3.39E-08GMOL/CC,
ASSUME INITIAL DRIVING FORCE IS HALF THE SOLUBILITY.
ASSUME TURBULENT FLOW INSIDE COUPONS.

TOTAL FLOW=14.179CC/S, ID FLOW/TOTAL FLOW= 0.946, ID MASS LOSS/TOTAL COUPON LOSS= 0.952

PATH	RESORF	F	RE	VEL	CC/S	%SATN	TTL- GMOL	COUPONS	GMOL/CM2/S
COUP. ID	4.14E+02	9.84E-03	4.17E+03	45.0	1.34E+01	1.15E-01	2.61E-08	2.61E-08	2.70E-10
COUP. OD	1.87E+01	1.65E+00	1.46E+01	1.9	1.28E-01	5.49E-01	1.19E-09	5.97E-10	4.79E-12
STRG. OD	2.83E+01	7.22E-01	3.33E+01	3.2	4.65E-01	2.87E-01	2.26E-09	0.	5.65E-12
CUT LAM.	4.79E+01	1.12E-01	1.43E+02	6.5	1.77E-01	4.73E-01	1.42E-09	7.12E-10	5.23E-10
CUT TRB.	4.79E+01	1.82E-02	3.55E+02	16.1	4.39E-01	2.96E-01	2.20E-09	1.10E-09	8.08E-10

APPENDIX T. DATA BOOKKEEPING PROGRAM LPLS

Calculation of Weight Loss

Generation of Data Tables

Graphing of Data

Least Squares Estimates of Local Rates

(Uses IMSL routines BECOVM, RLMUL;
also graphics routines from DISSPLA.)

Also in Appendix T: Microprobe graphing
PROGRAM PROBE.

```
C       LATEST REVISION APRIL 28, 1980
C       WRITTEN BY DON BAUER   UNIVERSITY OF WISCONSIN MADISON
C       SPRING 1979
        PROGRAM LPLS(DATA,TAPE5=DATA,OUTDAT,TAPE6=OUTDAT,OUTSUM,
       +TAPE7=OUTSUM,OUTERR,TAPE8=OUTERR,OUTPUT,TAPE9=OUTPUT,PRINT)
C******REQUIRES IMSL ROUTINE RLMUL--
C          COMPILE WITH CHATR I=LPLS,X=DAT,LIB=(DISSLIB,IMSL,
C              TV80LIB,ORDERLIB(NEEDS RLMUL)).GO / 1 1
C       PROGRAM TO READ IN WEIGHTS OF COUPONS AND ARRANGE IN TABLES
C       CALCULATES CHANGE SINCE LAST WEIGHING AND CUMULATIVE CHANGE
C       GRAPHS THE CUMULATIVE CHANGE VS CUMULATIVE TIME IN LOOP
C       CALLS IMSL ROUTINE RLMUL TO PERFORM LINEAR LEAST SQUARES ON
C       DATA TO GET EQUATION OF LINE WEIGHT LOSS VS DAYS
C       SET UP DROP FILE FOR DEBUGGING, AND SET UP GRAPHICS ROUTINES
90801 CALL CHANGE(4R+DAT)
      CALL KEEP80(1,3)
      CALL GFSIZE(3,30000008)
90803 CALL FR80ID(7HEXAMPLE,1,2,1)
90804 CALL PLTS
C     CALL COLORSORT(1)
      DIMENSION VEL(4),XDRAW2(30),XDRAW1(30),YDRAW1(30),YDRAW2(30)
      DIMENSION YDRAW5(5),YDRAW6(5),YDRAW7(5)
      DIMENSION INCLUD(5,14),  IFF(4),WRD(20,30),YDRAW3(30),YDRAW4(30)
      INTEGER M(17),IM(150),LET(34),STAR,BLANK,DASH,PLUS,ILET,ATT,HASH
      DIMENSION WEIGHT(4,16,2),CHANG(4,17,29),DUMMY(8),ANUM(20)
      DIMENSION NPTSEC(4), TI(16),CU(16),TIM(4,17,29),CUM(4,17,29)
      DIMENSION SUMM(4),CUMM(4),TIMES(4,2,29),IT(4),DEL(4)
      DIMENSION X1(128),X2(128),X3(128),X4(128),Y1(128),Y2(128),
     +Y3(128),Y4(128),RANGE(5),IPTEM(2,20),INSTOR(4),STORE1(4)
      DIMENSION IPTEMM(2,8),XDRWW(4,8),YDRWW(4,2,8),LINEPT(29)
      DIMENSION STORE(4,16,29,2),IBLANK(120),MARK(17),AR(10,20)
      DIMENSION SLOPE2(4,17,29),SL2STD(4,17,29)
      DIMENSION X(8,3),NBR(6),SLOPE(4,17,29),CEPT(4,17,29),
     +TEMP(3),XM(3),VCV(9),VARB(3),XYBAR(3),ANOVA(14),B(3,7),
     +INO(4),SLSTD(4,17,29),CEPSTD(4,17,29),NUSED(4,17,29)
      DIMENSION NPTTS(4), I18PAK(140),I9APAK(140),IV136(20),IV96(20),
     +SLOPEK(4),IPBRK(4),IPOMIT(4),RESID(4),IV65(20),IV45(20),IVELS(80)
      EQUIVALENCE (SLOPE2,CHANG)
      EQUIVALENCE (SL2STD,STORE)
      DATA NBR/2,0,0,1,1,1/,INO/1,2,3,4/,VEL/1.36,.65,.45,.96/
      DATA LET/"0","1","2","3","4","5","6","7","8","9","A",
     +"B","C","D","E","F","@","K","L","M","N","O","P","Q",
     +"R","S","T","U","V","W","X","Y","Z","#"/
      DATA ATT/"@"/,STAR/"*"/,BLANK/" "/,DASH/"-"/,PLUS/"+"/,ILET/"I"/
      DATA HASH/"#"/
      DATA DUMMY/7*0.,4./, WEIGHT/128*4./,CHANG/640*0./
      DATA ANOT/"NOT "/,SPAC/"     "/,RANGE/1,0,180,0.24/
      DATA IBLNK/" "/,TIMES/80*10./,IBLANK/129*" "/
      DATA MARK/"0","1","2","3","4","5","6","7","8","9","A","B","C","D",
     +"E","F","M"/
C       READ IN THESE NUMBERS:
C       IP IS INDEX FOR PULL #, IS FOR SECTION#, IN FOR COUPON #
C       COUPONS DENOTED 0-15 OR 1-16.
C       NPULL=TOTAL PULLS;   NB0 ,NB1: 1ST, LAST PULLS THESE CONDITIONS
C       NROW NUMBER OF ROWS; IRA4 ROW SPACING;      NCOL NO. OF COLS
C       IRA2 COL SPACING          ISTAR FLAG FOR STAR ON MULTIPLE POINTS
C       IAVG FLAG AND VARIABLE FOR AVERAGES
C       INUM1= NUMBER THE Y AXIS OF PRINTER PLOT??
C       IA4 FLAG =2 FOR ALL SETS ON ONE GRAPH
C       I0 FIRST COUPON TO AVERAGE IN SLOPE-AVERAGING
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C      IE LAST COUPON TO AVERAGE IN SLOPE-AVERAGING
       READ(5,20)NPULL,NB0,NB1,NROW,IRA4,NCOL,IRA2,ISTAR,IAVG,INUM1,IA4,
      +I0,IE
       IFRAME=0
       I0P1=I0+1
       IEP1=IE+1
C      RANGE(1)=       ABS(RANGE(2))=FIRST DAY, RANGE(3)=LAST DAY
C      IF RANGE(2) ZERO OR GREATER, PLOT LOSS VS TIME
C      IF RANGE(2) =-1.5 PLOT LOSS VS (TIME & SQRT(T))
C      IF RANGE(2) =-1 PLOT LOG(LOSS) VS LOG(TIME)
C      IF RANGE(2) =-.5 PLOT LOSS VS SQRT (TIME)
C      IF RANGE(2) =-2 PLOT LOSS**2 VS TIME
C         RANGE(4)=LOWER WEIGHT CHANGE LIMIT(MG), RANGE(5)=UPPER LIMIT
C
C      ALONG WITH RANGE ARRAY, LATER, READ LINEPT(I) FOR EACH POINT I:
C      IF LINEPT(I) IS   INCLUDE PT(I)?  BREAK AT PT(I)?  LINE FOLLOWS?
C            0                YES             NO               YES
C            1                YES             NO               NO
C            2                YES             NO               YES
C            3                YES             YES              NO
C            4                YES             YES              YES
C            5                NO              YES              NO
C            6                NO              YES              YES
C            7                NO              NO               NO
C            8                NO              NO               YES
       READ(5,2020)(RANGE(K),K=1,5)
2020   FORMAT(5F10.4)
       WRITE(6,22)NPULL
22     FORMAT(17X,"NUMBER OF PULLS IS ",I3)
C      IF(IAVG.GT.0)WRITE (6,23)SPAC
C      IF(IAVG.LE.0)WRITE (6,23)ANOT
23     FORMAT(17X,"THE DATA ARE ",A4," AVERAGED AND PUT IN COUPON #17")
C
       BIAS=1.E-8
C      BIAS IS INSIGNIFICANT COMPARED TO WEIGHT LOSSES BUT SERVES
C      AS A SIGNAL TO COMPUTER THAT NEW COUPON IS BEING USED
20     FORMAT(I3,2I1,1X,I3,1X,I2,1X,I3,1X,I2,1X,6(I2,1X))
C      READ START/FINISH TIME MODAYR.HR FOR 4 STRINGERS;
C      ALSO READ TMAX,TMIN, AND IDENTIFYING LABEL WORD
C      TMAX NEGATIVE IF THAT PULL NOT TO BE INCLUDED IN LEAST SQUARES.
       DO 19 I=1,NPULL
       READ(5,21)((TIMES(J,I0,I),I0=1,2),J=1,4)
19     READ(5,2100)IPTEM(1,I),IPTEM(2,I),(WRD(J,I),J=1,10)
2100   FORMAT(2I4,20A4)
21     FORMAT(8F10.2)
C
C
C      RECEIVE ALL WEIGHT DATA FOR EACH SECTION, IN TURN.
       DO 100 ISECT=1,4
       IPULL=-1
       IFLAG=-1
24     DO 25 J=1,16
C      TI, CU ARE RUNNING (CURRENT OR CUMULATIVE) TIME,WEIGHT CHANGE
       TI(J)=0.-BIAS
25     CU(J)=0.-BIAS
1      IF(IPULL.EQ.NPULL)GO TO 100
C      READ WEIGHTS FOR NEXT INTERVAL
       IPULL=IPULL+1
       IFLAG=IFLAG+1
       READ(5,10)(WEIGHT(ISECT,J,2),J=1,16)
```

```
      IPPLL=IPULL
      IF(IPULL.EQ.0)IPPLL=1
      IFFL=2
      IF(IPULL.EQ.0)IFFL=1
      DO 251 J=1,16
251   STORE(ISECT,J,IPPLL,IFFL)=WEIGHT(ISECT,J,2)
C     IFLAG=0--WEIGHT BEFORE EXPOSURE TO LITHIUM, DONT CALC CHANGE YET
      IF(IFLAG.EQ.0)GO TO 6
C     FIGURE OUT DEL, TIME IN LOOP BETWEEN THESE TWO WEIGHINGS.
      T1=TIMES(ISECT,1,IPULL)
      T2=TIMES(ISECT,2,IPULL)
      CALL TIMER(T1,T2,D)
      DEL(ISECT)=D
C
C     FIND WEIGHT CHANGE OVER THIS TIME INTERVAL
      DO 2 J=1,16
      CHANG(ISECT,J,IPULL)=WEIGHT(ISECT,J,1)-WEIGHT(ISECT,J,2)
      IF(CU(J).GE.0.)GO TO 26
C     STORE CUMULATIVE WEIGHT CHANGE AND TIME IN LOOP.
C***FOR TRACES TO BE SHIFTED TO PASS THROUGH ORIGIN, NEXT 4 LINES
C     MUST BE REWRITTEN.
C***FOR TRACES TO BE SHIFTED TO PASS THROUGH ORIGIN, SET NEXT 4 ELEMENTS
C        TO ZERO HERE. CUM, TIM ARE CUM. WEIGHT LOSS, EXPOSURE TIME.
C        FIRST TIME IS SET NEGATIVE AS FLAG INDICATING NEW COUPON
      CUM(ISECT,J,IPULL)=CHANG(ISECT,J,IPULL)
      TIM(ISECT,J,IPULL)=-DEL(ISECT)
      CU(J)=CUM(ISECT,J,IPULL)
      TI(J)=-DEL(ISECT)
      GO TO 2
26    CUM(ISECT,J,IPULL)=CU(J)+CHANG(ISECT,J,IPULL)
      CU(J)=CUM(ISECT,J,IPULL)
      TIM(ISECT,J,IPULL)=ABS(TI(J))+DEL(ISECT)
      TI(J)=TIM(ISECT,J,IPULL)
2     CONTINUE
C
C
C        DUMMY IS DUMMY ARRAY WHICH RECEIVES THE VALUES WHEN A
C     REPLACEMENT (SINGLE) COUPON IS PUT IN.
C     IF DUMMY VALUES ARE ALL ZERO, GOES TO 90 AND READS WHOLE NEW
C     DATA SET FOR THAT TEST SECTION
      READ(5,10)(DUMMY(JD),JD=1,8)
      SUM=0
      DO 3 J=1,8
3     SUM=SUM+DUMMY(J)
      ICOUP=8
      IF(SUM.EQ.-1.)GO TO 200
C     IF SUM IS -1, THIS TEST SECTION DATA ALL DONE.
      IF(SUM.EQ.-2.)GO TO 6
C     IF SUM IS -2, THIS INDICATES THAT NO REPLACEMENT COUPONS WERE USED
       IF(SUM)201,90,4
C     NEGATIVE (BUT NOT -1 OR -2) GIVES "FRESH" WEIGHT OF REPLACEMENT.
C     BETWEEN COUPON #1 AND #8. POSITIVE GIVES "FRESH" WEIGHT OF
C     REPLACEMENT COUPON BETWEEN #9 AND #16.  ICOUP IS AN INDEX.
C     IF SUM IS ZERO, ALL 16 COUPONS ARE FRESH-READ 16 NEW WEIGHTS.
201   ICOUP=0
4     CONTINUE
      DO 5 J=1,8
C     RESET CUMULATIVE TIME AND LOSS TO ZERO FOR THE FRESH COUPON.
      IF(DUMMY(J).NE.0)TI(J+ICOUP)=0.-BIAS
      IF(DUMMY(J).NE.0)CU(J+ICOUP)=0.-BIAS
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          IF(DUMMY(J).NE.0.)WEIGHT(ISECT,J+ICOUP,2)=ABS(DUMMY(J))
5         IF(DUMMY(J).NE.0.)STORE(ISECT,J+ICOUP,IPULL+1,1)=ABS(DUMMY(J))
C
C
C        STORE  THESE CURRENT WEIGHT  VALUES TO BE THE PREVIOUS VALUES
6         DO 7 J=1,16
7         WEIGHT(ISECT,J,1)=WEIGHT(ISECT,J,2)
         GO TO 1
C
C         READ NEW COUPONS WEIGHTS FOR A WHOLLY NEW TEST SET
 90       READ(5,10)(WEIGHT(ISECT,J,1),J=1,16)
         DO 91 J=1,16
91       STORE(ISECT,J,IPULL+1,1)=WEIGHT(ISECT,J,1)
10       FORMAT(8F10.8)
         GO TO 24
C        ALL THE DATA FOR THIS VELOCITY ARE IN.
100       CONTINUE
C
C        WRITE OUT THE INPUT DATA
         DO 89 IPULL=1,NPULL
         WRITE(7,71)IPULL,(WRD(J,IPULL),J=1,17),(IABS(IPTEM(K,IPULL)),
        +K=1,2),(TIMES(ISECT,1,IPULL),ISECT=1,4)
71       FORMAT("1",///////////,17X,"TEST PERIOD #",I2,/,17X,17A4,
        +/,17X,"MAX TEMP ",I5,"C -- MIN TEMP ",
        +I5,"C",/,/,17X,"START DATES AND ANY FRESH COUPONS ARE:",/,
        +17X,4(3X,F9.2,4X))
         SUM1=0.
         SUM=0.
         DO 72 IADD=1,4
         SUM1=SUM1+ABS(STORE(IADD,1,IPULL,1))
         DO 72 JADD=1,16
72       SUM=SUM+ABS(STORE(IADD,JADD,IPULL,1))
C        IF SUM NOT ZERO, AT LEAST ONE REPLACEMENT
C        IF SUM1 NOT ZERO AT LEAST ENTIRE SET REPLACED
         IF(SUM1.EQ.0)GO TO 75
         DO 73 INUM=1,16
73       WRITE(7,74)(INUM,STORE(ISECT,INUM,IPULL,1),ISECT=1,4)
74       FORMAT(17X,4("#",I2,F9.6,4X))
         GO TO 76
75       ICOUNT=0
         DO 751 ISECT=1,4
         STORE1(ISECT)=0.
751      INSTOR(ISECT)=0
         DO 77 INUM=1,16
         DO 77 ISECT=1,4
         IF(STORE(ISECT,INUM,IPULL,1).EQ.0.)GO TO 77
         STORE1(ISECT)=STORE(ISECT,INUM,IPULL,1)
         INSTOR(ISECT)=INUM
         ICOUNT=1
77       CONTINUE
         IF(ICOUNT.EQ.1)WRITE(7,74)(INSTOR(ISECT),STORE1(ISECT),ISECT=1,4)
76       WRITE(7,78)(TIMES(ISECT,2,IPULL),ISECT=1,4)
78       FORMAT(/,17X,"TEST PERIOD END DATES AND
        + COUPON WEIGHTS IN GRAMS:",/,17X,4(3X,F9.2,4X))
         DO 79 INUM=1,16
79       WRITE(7,74)((INUM,STORE(ISECT,INUM,IPULL,2),ISECT=1,4))
89       CONTINUE
         WRITE(7,899)
899      FORMAT("1",///////////)
C
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C
C     CHANGE DATA FROM GRAMS TO MILLIGRAMS
      DO 180 K1=1,4
      DO 180 K2=1,16
      DO 180 K3=1,NPULL
      CUM(K1,K2,K3)=1000.*CUM(K1,K2,K3)
 180  CHANG(K1,K2,K3)=1000.*CHANG(K1,K2,K3)
C
C     DETERMINE EXPOSURE TIME, THIS TEST PERIOD (USE FIRST COUPONS TIME)
 200  DO 205 IPULL=1,NPULL
      T1=TIMES(1,1,IPULL)
      T2=TIMES(1,2,IPULL)
      CALL TIMER(T1,T2,D)
      IF((-1)**IPULL.LT.0)WRITE(6,899)
      ID=D
      WRITE(6,150)IPULL,TIMES(1,2,IPULL),(IPTEM(KP,IPULL),KP=1,2),(WRD(JW,
     +IPULL),JW=1,18),ID
 150  FORMAT(/,17X,"PULL NUMBER ",I2,",  ON  ",F7.0,
     :/,17X,I4,"-",I4,"C, ",18A4,
     +/,17X,"MG LOSS IN ",I2," DAYS                 --
     +    CUMULATIVE LOSS MM.M MG @ DDD DAYS",/17X,"COUP",
     +" V=136 V= 96  V=65  V=45        V=136       V= 96       V=65
     +          V=45")
C
C     WRITE OUT THE DATA--CHANGES AND CUMULATIVE
      DO 204 INUM=1,16
      INUMM=INUM
C     THE COUPONS ARE SCRIBED 0-15 (COUPONS 1-16)
      DO 203 II=1,4
      IT(II)=TIM(II,INUM,IPULL)
 203  CONTINUE
 204  WRITE(6,11)INUMM,CHANG(1,INUM,IPULL),CHANG(4,INUM,IPULL),
     +CHANG(2,INUM,IPULL),CHANG(3,INUM,IPULL),
     +CUM(1,INUM,IPULL),IT(1),CUM(4,INUM,IPULL),
     +IT(4),CUM(2,INUM,IPULL),IT(2),
     +CUM(3,INUM,IPULL),IT(3)
 11    FORMAT(17X,I2,4F6.1,5X,4(F6.1," @",I3,1X))
C
C
      IF(IAVG.LE.0)GO TO 205
C     FIND TIME INTERVAL, THIS SECTION, THIS TEST PERIOD
      DO 164 I1=1,4
      IT(I1)=TIM(I1,1,IPULL)
      T1=TIMES(I1,1,IPULL)
      T2=TIMES(I1,2,IPULL)
      CALL TIMER(T1,T2,D)
      DEL(I1)=D
      CUMM(I1)=0.
      SUMM(I1)=0.
C     I0 IS FIRST, IAVG LAST COUPON TO AVERAGE.
      I2=I0
C
C
C     SUM THE DATA BEFORE GETTING AVERAGE
 160  I2=I2+1
      IF(CUM(I1,I2,IPULL).EQ.0..OR.I2.GT.(IAVG+1))GO TO 163
      CUMM(I1)=CUMM(I1)+CUM(I1,I2,IPULL)
      SUMM(I1)=SUMM(I1)+CHANG(I1,I2,IPULL)
      GO TO 160
C     TAKE AVERAGE OF DATA AND PUT IN COUPON 17
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163   IF(I2.EQ.3)I2=-1
      IF(I2-1-I0.LE.0)GO TO 1644
C
C     CONVERT TO AVERAGE LOSS PER SQUARE CM PER MONTH
      CUMM(I1)=CUMM(I1)/(I2-1-I0)/4.95
      SUMM(I1)=SUMM(I1)*30./4.95/(I2-1-I0)/DEL(I1)
1644  IF(IAVG.GT.0)CUM(I1,17,IPULL)=CUMM(I1)*4.95
      IF(IAVG.GT.0)TIM(I1,17,IPULL)=TIM(I1,1,IPULL)
164   CONTINUE
      IDEL=DEL(1)
      I2M2=I2-2
C     THIS AVERAGE RATE IS SECANT TO MASS LOSS CURVE, NOT THE TANGENT
C        WHICH WOULD BE THE TRUE RATE.  REMOVE THE 3 FOLLOWING COMMENT C'S
C        TO GET PRINTOUT OUT SECANT ESTIMATE OF RATE
C     WRITE(6,162)I0,I2M2,SUMM(1),SUMM(4),SUMM(2),SUMM(3),IDEL,
C    +CUMM(1),IT(1),CUMM(4),IT(4),
C    +CUMM(2),IT(2),CUMM(3),IT(3)
162   FORMAT(17X,I2,"-"I2,4F6.3,"/",I3,"DA;",F7.3,"@",I3,3(F7.3,"@",I3),
     +/,5X,"AVERAGE MILLIGRAMS PER SQUARE CM INSIDE WALL")
205   CONTINUE
      WRITE(6,899)
C
C
C     GRAPH THE DATA ??
C     IF NCOL IS BETWEEN ZERO AND 200 PLOT ON PRINTER.
      IF(NCOL.GE.200)GO TO 11022
      IF(NCOL.LE.0)GO TO 99999
C***************************************************
C                                                  *
C     PUT ROUTINE "LPGRAPH" HERE IF DESIRED        *
C      AND REMOVE ALL CALLS TO DISSPLA             *
C                                                  *
C***************************************************
C
C     READ FOR THIS RUN: BEGINNING, END PULL;
C     RANGE(1) IS MAXIMUM FLUX (UG/M2/S) FOR FLUX VS L/D GRAPH
C     X AXIS:FIRST DAY, LAST DAY: Y AXIS: LOW GRAMS/M2, HIGH GRAMS/M2
11022 READ(5,1104)NB0,NB1,(LINEPT(I29),I29=1,29),(RANGE(IR),IR=1,5)
      NPULL=NB1
      IF(NB0.EQ.0)GO TO 1292
1102  CONTINUE
C     LINE PRINTER GRAPH DONE
C
C
C
C     WRITE OUT SLOPES (FLUXES)
99999 CONTINUE
C99999 IF(IAVG.GT.0)WRITE(6,3558)I0P1,IEP1
3558  FORMAT(17X,"17TH COUPON AVERAGES COUPONS ",I3," TO ",I3)
C
      WRITE(6,35557)RANGE(2)
      WRITE(6,3557)
3560  NPULL=NB1
C     READ IN FIRST AND LAST PULL THIS SERIES,
C     READ IN MAX FLUX FOR L/D GRAPH (-NUMBER PLOT ONLY L/D GRAPH)
C     -100 OR +100 MEANS MAXIMUM FLUX 1.5 TIMES AVERAGE.
C     READ IN DUMMY, GRAPH FIRST,LAST DAY; LOW,HIGH MASS LOSS VALUE.
1104  FORMAT(2I2,6X,29I1,1X,5F8.4)
35557 FORMAT(17X,"RANGE(2)=",F6.1,/,20X,"IF NON-NEGATIVE, "
     +"PLOT W VS T",/,20X,"IF -.5,PLOT W VS SQRT(T); IF -1, PLOT LOG(W)"
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     +" VS LOG(T)",/,20X,"IF -1.5, PLOT W VS (T & SQRT(T)); IF -2,"
     +" PLOT W**2 VS T",/,17X,"FOLLOWING HEADINGS APPLY FOR W VS T:")
3557  FORMAT(17X,"FOLLOWING SLOPE IS
     +  UGRAMS/M2/SECOND,"/,
     +17X,"TSECTCOUP FROM   TO  PTS   SLOPE   SDEV     INTCPT    SDEV")
1103  CONTINUE
C
C
C
C     SET GRAPH LEGENDS
      CALL RESET("COMPLX")
      CALL LINES("X/D =  8$",I18PAK,1)
      CALL LINES("X/D = 12$",I18PAK,2)
      CALL LINES("X/D = 16$",I18PAK,3)
      CALL LINES("X/D = 20$",I18PAK,4)
      CALL LINES("X/D = 24$",I18PAK,5)
      CALL LINES("X/D = 28$",I18PAK,6)
      CALL LINES("X/D = 32$",I18PAK,7)
      CALL LINES("X/D = 36$",I18PAK,8)
      CALL LINES("X/D = 40$",I9APAK,1)
      CALL LINES("X/D = 44$",I9APAK,2)
      CALL LINES("X/D = 48$",I9APAK,3)
      CALL LINES("X/D = 52$",I9APAK,4)
      CALL LINES("X/D = 56$",I9APAK,5)
      CALL LINES("X/D = 60$",I9APAK,6)
      CALL LINES("X/D = 64$",I9APAK,7)
      CALL LINES("X/D = 68$",I9APAK,8)
C     CALL LINES("AVG:$",I9APAK,9)
      CALL LINES("V = 1.36 M/S$",IVELS,1)
      CALL LINES("V =  .96 M/S$",IVELS,2)
      CALL LINES("V =  .65 M/S$",IVELS,3)
      CALL LINES("V =  .45 M/S$",IVELS,4)
      CALL LINES("V = 1.36 M/S$",IV136,1)
      CALL LINES("V =  .96 M/S$",IV96,1)
      CALL LINES("V =  .65 M/S$",IV65,1)
      CALL LINES("V =  .45 M/S$",IV45,1)
C     IF RANGE(2) IS LESS THAN -10., DO NOT PERFORM LEAST
C        SQUARES OR GRAPH DATA;
C        RATHER PERFORM CALCULATIONS SPECIFIED HERE BY USER
C
C
C     ****************************************
C     *****************************************
C     TRIAL CALCULATIONS MADE HERE...
      IF(RANGE(2).GE.-10.)GO TO 11025
      IF(RANGE(2).NE.-11.)GO TO 11022
C     USER ROUTINE HERE
C
C
      GO TO 11022
C     ***********************************
C     ***********************************
11025 DO 1201 IS=1,4
      DO 12021 IN=1,16
      IF(IN.NE.1.AND.IN.NE.9)GO TO 11031
      CALL COMPLX
      CALL BASALF("STAND")
      CALL MIXALF("INSTR")
      CALL MX3ALF("L/CGR",1H@)
      IF(NCOL.GE.300)GO TO 11031
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C      AND DONT GRAPH ALL THE DATA -JUST SELECTED TRACES
       CALL NOBRDR
       CALL GRACE(0.)
       IF(RANGE(1).LT.0)GO TO 11031
C      RANGE(1) LT ZERO IF ONLY FLUX VS L/D  GRAPH NEEDED
       IFRAME=IFRAME+1
       IF(RANGE(2).GE.0)WRITE(9,11032)IFRAME,IS,IN
11032 FORMAT(" IFRAME=",I2,",IS=",I2,",IN=",I2,"LOSS VS TIME")
       IF(RANGE(2).EQ.-.5)WRITE(9,11035)IFRAME,IS,IN
       IF(RANGE(2).EQ.-1.5)WRITE(9,11036)IFRAME,IS,IN
11035 FORMAT(" IFRAME=",I2,",IS=",I2,",IN=",I2,",LOSS VS SQRT(T)")
11036 FORMAT(" IFRAME=",I2,",IS=",I2,",IN=",I2,
     +",LOSS = B*T + C*SQRT(T) + A")
       IF(RANGE(2).EQ.-1)WRITE(9,11033)IFRAME,IS,IN
11033 FORMAT(" IFRAME=",I2,",IS=",I2,",IN=",I2,",LOG(LOSS) VS LOG TIME")
       IF(RANGE(2).EQ.-2.)WRITE(9,11034)IFRAME,IS,IN
11034 FORMAT(" IFRAME=",I2,",IS=",I2,",IN=",I2,
     +",LOSS**2 VS TIME")
       CALL TITLE(1H ,1,
     +"TIME, SECONDS * 10(E)-5(EX)$",
     +100,"MASS LOSS, G/M(E)2(EX)$",100,6.,8.)
       CALL HEADIN("316 STAINLESS STEEL MASS LOSS$",100,3,2)
       CALL HEADIN("IN LIQUID LITHIUM$",100,3,2)
       RANG2=RANGE(2)
       IF(RANGE(2).LT.0)RANG2=0.
       RANGEX=(ABS(RANGE(3))-RANG2)/5.
       RANGEY=(RANGE(5)-RANGE(4))/5.
       IF(RANGE(2).GE.0)CALL GRAF(RANG2,RANGEX,ABS(RANGE(3)),
     +RANGE(4),RANGEY,RANGE(5))
       IF(RANGE(2).EQ.-.5)CALL GRAF(0.,SQRT(RANGEX),SQRT(ABS(RANGE(3))),
     +RANGE(4),RANGEY,RANGE(5))
       IF(RANGE(2).EQ.-1)CALL LOGLOG(1.,2.,.1,2.)
       IF(RANGE(2).EQ.-1.5)CALL GRAF(0.,RANGEX,ABS(RANGE(3)),
     +0.,RANGEY,RANGE(5))
       IF(RANGE(2).EQ.-2)CALL GRAF(0.,RANGEX,ABS(RANGE(3)),
     +0.,RANGEY,(RANGE(5)**2))
       CALL DFRAME
       IF(IN.EQ.1)ILINES=0
C      ****NOTE THAT INPUT DATA IS IN GRAMS,
C ****TABULAR WEIGHT LOSS DATA IS IN MILLIGRAMS, DAYS
C ****GRAPHICAL (DISSPLA ROUTINES) DATA GRAMS, SQ METERS, SECONDS
C ****TIME IS CALCULATED IN UNITS OF(100,000 SECONDS)
C
11031 IP=NB0-1
1203    NBR(3)=0
       I2OR3=2
       IF(RANGE(2).EQ.-1.5)I2OR3=3
       NLASTP=IP+1
1204    IF(IP.EQ.NPULL.AND.NBR(3).LE.I2OR3)GO TO 1202
       IF(IP.EQ.NPULL)GO TO 1205
       IP=IP+1
       IFIP=0
C      IF TIME LE 0, FRESH COUPON; GO TO 12041
       IF(TIM(IS,IN,IP).LE.0..AND.NBR(3).EQ.0)GO TO 12041
C      IF NUMBER OF DATA POINTS (NBR(3)) LESS THAN THREE, NO LINE, GO TO 1203
       IF(TIM(IS,IN,IP).LE.0..AND.NBR(3).LE.I2OR3)IP=IP-1
       IF(TIM(IS,IN,IP).LE.0..AND.NBR(3).LE.I2OR3)GO TO 1203
       IF(ABS(4.5-LINEPT(IP)).LE.1.6.AND.IP.NE.NLASTP.AND.IP.NE.NPULL)
     +IFIP=1
C      IF LINEPT(IP) IS 3,4,5,6 BREAK LINE HERE
```

```
C         DELTA TEMPERATURE CHANGED, SO END THIS LINE, RESTART
C         ANOTHER LINE ON SAME POINT (THEREFORE IP=IP-2, SO IP-1 WILL
C         ALSO BE ON NEW LINE
C       IF  THERE IS CHANGE IN DELTA TEMP, IFIP=1, CALCULATE LS LINE
        IF(TIM(IS,IN,IP).GT.0.)GO TO 12041
C       IF TIM NEGATIVE, NEW COUPON, END THIS LINE, START ANOTHER
C       WITH NEXT POINT  THEREFORE IP=IP-1
        IF(IFIP.EQ.0)IP=IP-1
        GO TO 1205
C       NBR(3) IS THE NUMBER OF PULLS (DATA POINTS) ON THIS LINE
C
C       COUNT ANOTHER DATA POINT FOR THIS LINE, RECORD ITS X,Y COORDINATES
  12041 IF(LINEPT(IP).GE.5)GO TO 1204
C       IF LINEPT(IP) IS 5,6,7,OR 8 DO NOT INCLUDE IN LEAST SQUARES
        NBR(3)=NBR(3)+1
        X(NBR(3),1)=ABS(TIM(IS,IN,IP))*.864
C AREA FACTOR: 4.91CMSQ/COUP .491=10+3MG/G * 10-4CMSQ/M2 /4.91CMSQ
        IF(RANGE(2).EQ.-1.)X(NBR(3),1)=ALOG(X(NBR(3),1))
        IF(RANGE(2).EQ.-.5)X(NBR(3),1)=SQRT(X(NBR(3),1))
        X(NBR(3),2)=CUM(IS,IN,IP)/.491
        IF(RANGE(2).EQ.-1.)X(NBR(3),2)=ALOG(X(NBR(3),2))
        IF(RANGE(2).EQ.-2.)X(NBR(3),2)=X(NBR(3),2)**2
        IF(RANGE(2).EQ.-1.5)X(NBR(3),3)=X(NBR(3),2)
        IF(RANGE(2).EQ.-1.5)X(NBR(3),2)=SQRT(X(NBR(3),1))
        NBR(1)=I2OR3
        NBR(2)=NBR(3)
        IF(IFIP.EQ.0)GO TO 1204
        IF(NBR(3).LE.I2OR3)IP=IP-1
        IF(NBR(3).LE.I2OR3)GO TO 1203
        IF(IP-NLASTP.LT.I2OR3)GO TO 1203
C       IF THERE WAS NO CHANGE IN DELTA TEMP, CONTINUE LEAST SQUARES
C       IF THERE WAS A CHANGE IN DELTA TEMP, BUT LESS THAN 3 POINTS, START
C            A NEW LEAST SQUARES LINE
C       IF WAS A CHANGE IN DELTA TEMP, AFTER 3 OR MORE PTS, THEN FIND LINE.
C
C
C       USE LEAST SQUARES TO FIGURE EQUATION OF LINE FOR EACH
C       COUPON, THEN SAVE THE VALUE AFTER PRINTING IT
   1205 IF(IP+1-NLASTP.LE.I2OR3)GO TO 3661
C       DO NOT TRY LEAST SQUARES UNLESS ONE EXTRA POINT
C       THAT IS, THREE POINTS NEEDED FOR A 2 PARAMETER LINE
        CALL BECOVM(X,8,NBR,TEMP,XYBAR,VCV,IER)
        CALL RLMUL(VCV,XYBAR,NBR(3),(I2OR3-1),.10,ANOVA,B,3,VARB,IER)
C       WRITE OUT SLOPES --CONVERTED FROM LEAST SQUARES RESULTS
C          WHICH ARE G/M2/(100000S), TO UG/M2/S BY MULTIPLYING SLOPES
C          AND SLOPE STD DEVIATIONS BY 10.
        B11T10=B(1,1)*10.
        B21T10=B(2,1)*10.
        B14T10=B(1,4)*10.
        B24T10=B(2,4)*10.
        IF(RANGE(2).NE.-1.5)
       +WRITE(6,3556)IS,IN,NLASTP,IP,NBR(3),B11T10,B14T10,B(2,1),B(2,4)
        IF(RANGE(2).EQ.-1.5)WRITE(6,3556)
       +IS,IN,NLASTP,IP,NBR(3),B11T10,B14T10,B21T10,B24T10,B(3,1),B(3,4)
C       IF(IAVG.NE.0.AND.IN.EQ.16)WRITE(6,3558)I0P1,IEP1
   3556 FORMAT(15X,5I5,2X,F9.4,"+",F7.3,F10.3,"+",F7.3,3X,F9.4,"+",F7.3)
C       STORE INTERCEPT, SLOPE, STD DEVIATIONS & NO. PTS. THIS DATA LINE
        DO 1206 IX=NLASTP,IP
        CEPT(IS,IN,IX)=B(I2OR3,1)
        CEPSTD(IS,IN,IX)=B(I2OR3,4)
```

```
C      ***CHANGE SLOPE (FLUX) FROM GRAMS PER SQ M PER(100,000SECONDS)
C         TO MICROGRAMS PER SQ M PER SECOND, BY MULTIPLYING B(1,1) BY 10.
C      THE STANDARD DEVIATIONS OF SLOPES MUST ALSO BE MULTIPLIED BY TEN.
C*****************************************
C*****************************************:
       SLOPE2(IS,IN,IX)=10.*B(2,1)
       SL2STD(IS,IN,IX)=10.*B(2,4)
       SLSTD(IS,IN,IX)=10.*B(1,4)
       NUSED(IS,IN,IX)=NBR(3)
 1206  SLOPE(IS,IN,IX)=10.*B(1,1)
C
       IF(IN.EQ.1)ILINES=ILINES+1
       IF(IN.EQ.1)IPTEMM(1,ILINES)=NLASTP
       IF(IN.EQ.1)IPTEMM(2,ILINES)=IP
C      DRAW THE LEAST SQUARES LINE JUST CALCULATED
       ITTIM=0
       DO 3660 ITIM=NLASTP,IP
       I1MN=ITIM+1-NLASTP
       XDRAW1(I1MN)=ABS(TIM(IS,IN,ITIM))*.864
       IF(RANGE(2).EQ.-.5)XDRAW1(I1MN)=SQRT(XDRAW1(I1MN))
       IF(RANGE(2).NE.-1.)YDRAW2(I1MN)=B(2,1)+B(1,1)*XDRAW1(I1MN)
       IF(RANGE(2).EQ.-1.5)YDRAW2(I1MN)=B(3,1)+B(1,1)*XDRAW1(I1MN)
      ++B(2,1)*SQRT(XDRAW1(I1MN))
 3660  IF(RANGE(2).EQ.-1)YDRAW2(I1MN)=EXP(B(2,1))*EXP(B(1,1)*
      +ALOG(XDRAW1(I1MN)))
C      IF(-1)**LINEPT IS POSITIVE, DRAW LINE, OTHERWISE DO NOT
       IF((-1)**LINEPT(NLASTP).EQ.1.AND.RANGE(2).GE.0..AND.
      +NCOL.LT.300.AND.RANGE(1).GE.0)CALL CURVE(XDRAW1,YDRAW2,I1MN,0)
 3661  IF(IFIP.EQ.1)IP=IP-1
C      IF THERE WAS BREAK IN SLOPE, IFIP=1, USE POINT AGAIN IN NEXT LINE
       IF(IP.LT.NPULL)GO TO 1203
 1202  CONTINUE
C
C
C      SET NUMBER-LEGENDS ON THE GRAPHS
       IF(RANGE(1).LT.0)GO TO 12021
       IF(IN.NE.8.AND.IN.NE.16)GO TO 12021
       NTIMES=NPULL+1-NB0
       IF(IN.EQ.8)IN81=1
       IF(IN.EQ.8)IN82=8
       IF(IN.EQ.16)IN81=9
       IF(IN.EQ.16)IN82=16
       DO 12031 IN8=IN81,IN82
       IP81=NPULL-NB0+1
       DO 12032 IP8=1,IP81
       IP8M=IP8+NB0-1
       XDRAW1(IP8)=.864*ABS(TIM(IS,IN8,IP8M))
       IF(RANGE(2).EQ.-.5)XDRAW1(IP8)=SQRT(XDRAW1(IP8))
       YDRAW2(IP8)=CUM(IS,IN8,IP8M)/.491
 12032 IF(RANGE(2).EQ.-2.)YDRAW2(IP8)=YDRAW2(IP8)**2
C      CALL COLOR(IN8-1)
       CALL MARKER(IN8-1)
 12031 IF(NCOL.LT.300.)CALL CURVE(XDRAW1,YDRAW2,
      +IP81,-1)
       IF(NCOL.GE.300.OR.(IN.NE.8.AND.IN.NE.16))GO TO 12021
       IF(IN.EQ.8)CALL LEGEND(I18PAK,8,4.0,1.5)
       IF(IN.EQ.16)CALL LEGEND(I9APAK,8,4.0,1.5)
       ILD1=I0*4+6
       ILD2=(IAVG+1)*4+6
       CALL RESET("COMPLX")
```

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C      IF(IN.EQ.16)CALL MESSAG("          $",100,4.0,1.5)
C      IF(IN.EQ.16)CALL INTNO(ILD1,"ABUT","ABUT")
C      IF(IN.EQ.16)CALL MESSAG("-$",100,"ABUT","ABUT")
C      IF(IN.EQ.16)CALL INTNO(ILD2,"ABUT","ABUT")
       CALL COMPLX
       CALL MESSAG("PULLS  TEMPS$",100,3.5,1.)
       DO 12034 IPLTMP=1,ILINES
       YLOC=1-.18*IPLTMP
       CALL RESET("COMPLX")
       IF(IPTEMM(1,IPLTMP).LT.10)CALL MESSAG(" $",100,3.5,YLOC)
       IF(IPTEMM(1,IPLTMP).GE.10)CALL INTNO(IPTEMM(1,IPLTMP),3.5,YLOC)
       IF(IPTEMM(1,IPLTMP).LT.10)CALL INTNO(IPTEMM(1,IPLTMP),"ABUT",
      +"ABUT")
       CALL MESSAG("-$",100,"ABUT","ABUT")
       IF(IPTEMM(2,IPLTMP).LT.10)CALL MESSAG(" $",100,"ABUT","ABUT")
       CALL INTNO(IPTEMM(2,IPLTMP),"ABUT","ABUT")
       CALL MESSAG("  :$",100,"ABUT","ABUT")
       IPTLOC=IPTEMM(1,IPLTMP)+1
       CALL INTNO(IPTEM(1,IPTLOC),"ABUT","ABUT")
       CALL MESSAG("-$",100,"ABUT","ABUT")
       CALL INTNO(IPTEM(2,IPTLOC),"ABUT","ABUT")
 12034 CALL MESSAG("C$",100,"ABUT","ABUT")
       IF(IS.EQ.1)CALL STORY(IV136,1,3.5,1.3)
       IF(IS.EQ.2)CALL STORY(IV65,1,3.5,1.3)
       IF(IS.EQ.3)CALL STORY(IV45,1,3.5,1.3)
       IF(IS.EQ.4)CALL STORY(IV96,1,3.5,1.3)
       IF(RANGE(2).GE.0)CALL MESSAG("MODEL: W=BT+A$",100,1.,.7)
       IF(RANGE(2).EQ.-.5)CALL MESSAG("MODEL: W=B*SQRT(T)+A$",100,1.,.7)
       IF(RANGE(2).EQ.-1.)CALL MESSAG("MODEL: W=A*T**B$",100,1.,.7)
       IF(RANGE(2).EQ.-1.5)CALL MESSAG("MODEL: W=BT+C*SQRT(T)+A$",
      +100,1.,.7)
       IF(RANGE(2).EQ.-2.)CALL MESSAG("MODEL: W**2=BT+A$",100,1.,.7)
       CALL COMPLX
       IF(IN.EQ.8.OR.IN.EQ.16)CALL ENDPL(0)
 12021 CONTINUE
 1201  CONTINUE
C
C
C
C      GRAPH MASS LOSS RATE VS. POSITION
       IF(NCOL.GE.300)GO TO 1312
       LPULL=NB0
       DO 12015 IS=1,4
 12015 SLOPEK(IS)=SLOPE(IS,1,NB0)
       DO 13111 IPULL=NB0,NB1
       ISLOPE=0
       DO 12017 IS=1,4
       IF(SLOPEK(IS).NE.SLOPE(IS,1,IPULL+1))ISLOPE=1
 12017 IF(SLOPEK(IS).NE.SLOPE(IS,1,IPULL+1))SLOPEK(IS)
      +=SLOPE(IS,1,IPULL+1)
       IF(ISLOPE.EQ.0)GO TO 13111
       DO 1311 IPLOT=1,4
       IFRAME=IFRAME+1
       WRITE(9,12018)IFRAME,ISECT,IPLOT
 12018 FORMAT(" IFRAME=",I2,", ISECT=",I2,",IPLOT=",I2)
       CALL TITLE(1H ,1,
      +"DOWNSTREAM POSITION, X/D$",100,"MASS LOSS RATE, @M)G/
      +M(E)2(EX)/S$",100,6.,8.)
       CALL HEADIN("316 STAINLESS STEEL MASS LOSS$",100,3,2)
       CALL HEADIN("IN LIQUID LITHIUM$",100,3,2)
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C     DETERMINE ROUNDED VALUE FOR MAXIMUM FLUX. FOR GRAPH
      FLMIT1=1.E+10
      FLXMAX=0.
      DO 12009 I12009=1,4
12009 NPTSEC(I12009)=16
      FFLIM=0.
      DO 12010 NCOUP=1,16
      IF(NCOUP.GE.I0P1.AND.NCOUP.LE.IEP1)FFLIM=
     +FFLIM+SLOPE(1,NCOUP,IPULL)
      IF(SLOPE(1,NCOUP,IPULL).GT.FLXMAX)FLXMAX=SLOPE(1,NCOUP,IPULL)
      IF(SLOPE(2,NCOUP,IPULL).GT.0.AND.SLOPE(2,NCOUP,IPULL).LT.
     +FLMIT1)FLMIT1=SLOPE(2,NCOUP,IPULL)
      IF(SLOPE(3,NCOUP,IPULL).GT.0.AND.SLOPE(3,NCOUP,IPULL).LT.
     +FLMIT1)FLMIT1=SLOPE(3,NCOUP,IPULL)
12010 IF(SLOPE(4,NCOUP,IPULL).GT.FLXMAX)FLXMAX=SLOPE(4,NCOUP,IPULL)
      IF(ABS(RANGE(1)).EQ.1000.)FLXMAX=FFLIM/(1+IEP1-I0P1)*1.5
      IFLXMX=FLXMAX/.5
      FLIMIT=.5*(IFLXMX+1.)
      FLXSPC=.5
      IF(IFLXMX.GT.20)FLXSPC=.2
      IF(IFLXMX.GT.40)FLXSPC=.4
      IF(RANGE(1).NE.0.AND.ABS(RANGE(1)).NE.1000)FLIMIT=ABS(RANGE(1))
      IF(IPLOT.LT.3)CALL GRAF(0.,10.,70.,0.,FLXSPC,FLIMIT)
      IF(IPLOT.GE.3)CALL LOGLOG(8.,6.,FLMIT1,12.)
      CALL DFRAME
      LOWUSE=16
      DO 13109 IS13=1,4
13109 IF(NUSED(IS13,1,IPULL).LT.LOWUSE)LOWUSE=NUSED(IS13,1,IPULL)
      DO 1310 IN=1,16
C     COUPON CENTERS AT (1+N)INCHES FROM CONTRACTION AT STOP
C            (1.5 INCHES UPSTREAM OF FIRST COUPON LEADING EDGE)
      XDRAW1(IN)=1./.2445+IN/.2445
      YDRAW1(IN)=SLOPE(1,IN,IPULL)
      YDRAW2(IN)=SLOPE(2,IN,IPULL)
      YDRAW3(IN)=SLOPE(3,IN,IPULL)
      YDRAW4(IN)=SLOPE(4,IN,IPULL)
      DO 1310 IS1310=1,4
      IF(NUSED(IS1310,IN,IPULL).LT.LOWUSE.AND.
     +IPLOT.NE.1.AND.NPTSEC(IS1310).EQ.16)NPTSEC(IS1310)=IN-1
      IF(IPULL.EQ.LPULL.OR.IN.EQ.1)GO TO 1310
      IF(NUSED(IS1310,IN,LPULL).GT.NUSED(IS1310,(IN-1),LPULL)
     +.AND.NPTSEC(IS1310).EQ.16)NPTSEC(IS1310)=IN-1
1310  CONTINUE
      XDRAW2(1)=8.
      XDRAW2(2)=64.
      YDRAW5(1)=FLIMIT
      YDRAW5(2)=FLIMIT/(64./8.)**.5
      YDRAW6(1)=FLIMIT
      YDRAW6(2)=FLIMIT/(64./8.)**.3333
      YDRAW7(1)=FLIMIT
      YDRAW7(2)=FLIMIT/(64./8.)**.25
      IF(IPLOT.EQ.4)CALL CURVE(XDRAW2,YDRAW5,2,0)
      IF(IPLOT.EQ.4)CALL CURVE(XDRAW2,YDRAW6,2,0)
      IF(IPLOT.EQ.4)CALL CURVE(XDRAW2,YDRAW7,2,0)
C
C
      CALL MARKER(1)
      CALL CURVE(XDRAW1,YDRAW1,NPTSEC(1),-1)
      CALL MARKER(4)
      CALL CURVE(XDRAW1,YDRAW4,NPTSEC(4),-1)
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      CALL MARKER(2)
      CALL CURVE(XDRAW1,YDRAW2,NPTSEC(2),-1)
      CALL MARKER(3)
      CALL CURVE(XDRAW1,YDRAW3,NPTSEC(3),-1)
      CALL LEGEND(IVELS,4,4,1)
      CALL RESET("COMPLX")
      IF(IPLOT.GE.3)CALL MESSAG("LOG-LOG PLOT$",100,.2,1.2)
      IF(IPLOT.EQ.4)CALL MESSAG(" FOR COMPARISON,$",100,.2,.7)
      IF(IPLOT.EQ.4)CALL MESSAG("LINES HAVE SLOPES$",100,.2,.5)
      IF(IPLOT.EQ.4)CALL MESSAG("-1/2, -1/3, -1/4$",100,.2,.3)
      CALL COMPLX
      CALL MESSAG("EXP. DATA$",100,4.,.7)
      CALL MESSAG("PULLS: $",100,4.,.45)
      CALL INTNO(LPULL,"ABUT","ABUT")
      CALL MESSAG("-$",100,"ABUT","ABUT")
      IPUL=IPULL
      IF(ABS(4.5-LINEPT(IPULL+1)).LT.1.6.AND.(IPULL+1).NE.NB1)
     +IPUL=IPULL+1
      CALL INTNO(IPUL,"ABUT","ABUT")
      CALL MESSAG("TEMPS:$",100,4.,.2)
      CALL INTNO(IPTEM(1,IPULL),"ABUT","ABUT")
      CALL MESSAG("-$",100,"ABUT","ABUT")
      CALL INTNO(IPTEM(2,IPULL),"ABUT","ABUT")
1311  CALL ENDPL(0)
      IF(ISLOPE.EQ.1)LPULL=IPULL+1
13111 CONTINUE
C
C
C
C
1312  IAVV=0
C     CHECK FROM PULL NB0 TO NB-1
C     LOOK FOR BREAK IN LINE(SLOPE=0) OR WAIT TILL NB1-1
C     THEN FOR EACH TEST SECTION FIGURE THE AVERAGE AND HAVE IT
C     PRINTED OUT--THE AVERAGE SLOPE FROM COUPONS I0 TO IE
      ILOGN=0
      DO 1301 IPULL=NB0,NB1
C     IPMIN, IPMAX ARE LOWEST,HIGHEST PULL WHICH ALL FOUR SECTIONS
C           HAVE IN COMMON
      IPMIN=0
      IPMAX=100
      SUMSL=0.
      DO 12011 IT=1,4
12011 SUMSL=SUMSL+ABS(SLOPE(IT,1,IPULL)-SLOPE(IT,1,IPULL+1))
      IF(IPULL.NE.(NB1).AND.SUMSL.LE.1.E-20)GO TO 1301
1302  IAVV=IAVV+1
      ILOGN=ILOGN+1
      DO 1300 IS=1,4
      DIV=0.
         SSQ=0.
      FACTOR=1.
      SSUM=0.
C     AVERAGE THE SLOPES OF THE COUPONS FROM I0 TO IE
C     AVERAGE THE SLOPE BETWEEN ARRAY ELEMENTS I0P1 AND IEP1
      DO 1290 IN=I0P1,IEP1
C     IF THE SLOPE IS ZERO, MEANS CHANGE IN EXP. CONDITIONS, DO NOT
C     AVERAGE ACROSS THE CHANGE
      IF(SLOPE(IS,IN,IPULL).EQ.0.)FACTOR=0.
      SSQ=SSQ+FACTOR*SLOPE(IS,IN,(IPULL))**2
      DIV=DIV+FACTOR
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1290  SSUM=SSUM+FACTOR*SLOPE(IS,IN,(IPULL))
      IF(DIV.EQ.0)DIV=1.E-10
C     GET THE STANDARD DEVIATION
      SIGG=SQRT((SSQ-SSUM**2/DIV)/(DIV+1.))
      AVGG=SSUM/DIV
      XDRWW(IS,ILOGN)=VEL(IS)
      YDRWW(IS,1,ILOGN)=AVGG
C
C
      YDRAW4(IS)=AVGG
      XDRAW1(IS)=VEL(IS)
      IF(AVGG.LE.0.)GO TO 1300
      X(IS,2)=ALOG(AVGG)
      X(IS,1)=ALOG(VEL(IS))
      IPEND=IPULL
      IPFRST=IPULL
      DO 12091                      I12=1,20
      IF(SLOPE(IS,1,I12).EQ.SLOPE(IS,1,IPULL).AND.I12.GT.IPEND)
     +IPEND=I12
12091 IF(SLOPE(IS,1,I12).EQ.SLOPE(IS,1,IPULL).AND.I12.LT.IPFRST)
     +IPFRST=I12
C     IF THERE WAS A BREAK IN THE SLOPE AT END OF LINE, BE SURE
C        TO INCLUDE THE EXTRA POINT, ALTHOUGH IT'S SLOPE HAS BEEN
C        REWRITTEN TO INCLUDE IT IN THE NEXT LINE SEGMENT
      IPP1=IPEND+1
      IF(ABS(4.5-LINEPT(IPPL)).LE.1.6.AND.SLOPE(IS,1,IPPL).NE.0
     +.AND.SLOPE(IS,1,IPP1).NE.SLOPE(IS,1,IPULL))IPEND=IPP1
      NDLAST=DIV+I0
      IF(IPFRST.GT.IPMIN)IPMIN=IPFRST
      IF(IPEND.LT.IPMAX)IPMAX=IPEND
      IF(ABS(4.5-LINEPT(IPMAX+1)).LE.1.6.AND.LINEPT(IPMAX+1)
     +.LE.4)IPMAX=IPMAX+1
      WRITE(6,1291)IS,AVGG,SIGG,I0P1,NDLAST,IPFRST,IPEND
      WRITE(7,1291)IS,AVGG,SIGG,I0P1,NDLAST,IPFRST,IPEND
C     IF(IN.EQ.16.AND.IAVG.GT.0)WRITE (6,3558)I0P1,IEP1
C
C
C
C     WRITE OUT RESIDUALS
      IF(IS.NE.1)GO TO 1300
      DO 12081 IPLLL=IPMIN,IPMAX
      IPDIV2=IPLLL/2
      IPDIV2=IPDIV2*2
      IF(IPDIV2.NE.IPLLL)WRITE(8,899)
      WRITE(8,12002)IPLLL,IPMIN,IPMAX
      IPLLS=0
      IPLS=0
      DO 12004 IPL=IPMIN,IPMAX
      IF(LINEPT(IPL).LE.4)GO TO 12005
      IPLS=IPLS+1
      IPOMIT(IPLS)=IPL
12005 IF(ABS(4.5-LINEPT(IPL)).GE.1.6)GO TO 12004
C     BREAK LINE HERE IF LINEPT IS 3,4,5, OR 6
      IF(IPL.EQ.NB0.OR.IPL.EQ.NB1)GO TO 12004
C     IF BREAK IN SLOPE IS AT BEGINNING OR END THIS PULL SET, DISREGARD.
      IPLLS=IPLLS+1
      IPBRK(IPLLS)=IPL
12004 CONTINUE
      IF(IPLS.NE.0)WRITE(8,12013)(IPOMIT(IPP),IPP=1,IPLS)
      IF(IPLLS.NE.0)WRITE(8,12014)(IPBRK(IPP),IPP=1,IPLLS)
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12013 FORMAT(17X,"PULL OMITTED FROM LEAST SQUARES:",5(I3))
12014 FORMAT(17X," FORCE BREAK IN SLOPE AT PULL:",5(I3))
12002 FORMAT(//,17X,"DEVIATIONS, MG/COUPON (LS PREDICT-DATA)",
     +/,17X,"PULL #",I2,"; DEVIATIONS FROM LEAST SQUARE LINES.",/,
     +17X," TEST PERIOD BETWEEN PULLS #",I2,"-",I2,/)
      NTRY=1
      IF(ABS(4.5-LINEPT(IPLLL)).LE.1.6.AND.IPLLL.NE.IPMIN)NTRY=2
      IPUL=IPLLL
      IF(NTRY.EQ.2)IPUL=IPLLL-1
      ISSTAR=0
      DO 12008 INN=1,16
      DO 12007 ISS=1,4
C     PREDICTION USING THIS PULL'S ( LAST PULL IF BREAK IN SLOPE HERE)
C        SLOPE,INTERCEPT;  THIS PULL'S TIME
      PREDICT=CEPT(ISS,INN,IPUL)+SLOPE(ISS,INN,IPUL)/10.
     +*ABS(TIM(ISS,INN,IPLLL))*.864
      RESID(ISS)=PREDICT*.491-CUM(ISS,INN,IPLLL)
      NPTTS(ISS)=NUSED(ISS,INN,IPUL)
      IF(ABS(RESID(ISS)).LT.1.E-4.OR.NPTTS(ISS).EQ.0)ISSTAR=1
      IF(ABS(RESID(ISS)).LT.1.E-4.OR.NPTTS(ISS).EQ.0)NPTTS(ISS)=0
12007 IF(ABS(RESID(ISS)).LT.1.E-4.OR.NPTTS(ISS).EQ.0)RESID(ISS)=1.E+12
12008 WRITE(8,12006)(INN,((NPTTS(ISS),RESID(ISS)),ISS=1,4))
12016 IF(ISSTAR.EQ.1)WRITE(8,12118)
12001 CONTINUE
12118 FORMAT(17X,"* INDICATES NO PREDICTION;LESS THAN 3 PTS")
12006 FORMAT(17X,"#",I2,4(I2,"PTS",F7.3,3X))
1300  CONTINUE
C     AFTER LEAST SQUARES RESULTS PRINTED, TELL IF ANY PULLS OMITTED
      DO 12054 IOMIT=NLASTP,IP
      IF(LINEPT(IOMIT).GE.5)WRITE(6,12051)IOMIT
      IF(LINEPT(IOMIT).GE.5)WRITE(7,12051)IOMIT
12051 FORMAT(17X,"PULL #",I2," OMITTED FROM LEAST SQUARES.")
12054 CONTINUE
      IF(AVGG.LE.0)GO TO 1301
C     DO NOT TRY TO USE LOG-LOG PLOT IF RATE IS  UNDETERMINED YET.
      NBR(2)=4
      NBR(3)=4
      CALL BECOVM(X,8,NBR,TEMP,XYBAR,VCV,IER)
      CALL RLMUL(VCV,XYBAR,NBR(3),1,.10,ANOVA,B,2,VARB,IER)
      IPTEMM(1,ILOGN)=IPTEM(1,IPULL)
      IPTEMM(2,ILOGN)=IPTEM(2,IPULL)
      EB21=EXP(B(2,1))
      WRITE(6,12055)IPULL,IPTEM(1,IPULL),IPTEM(2,IPULL),
     +I0P1,IEP1,B(1,1),B(1,4),B(2,1),B(2,4),EB21
      WRITE(7,12055)IPULL,IPTEM(1,IPULL),IPTEM(2,IPULL),
     +I0P1,IEP1,B(1,1),B(1,4),B(2,1),B(2,4),EB21
12055 FORMAT(17X,"PULL ",I2," TEMPS ",I4,"-",I4,"C  COUPONS ",I2,"-",I2,
     +/,16X," VELOCITY EXPONENT ",F6.3,"+/-",F6.4,/,
     +16X," LOG A=",F6.3,"+/-",F6.3,", A=",E10.2)
      IF(NCOL.GE.300)GO TO 1301
C
C     LOG-LOG PLOT OF MEAN RATE VS VELOCITY
      CALL MIXALF("INSTR")
      IFRAME=IFRAME+1
      WRITE(9,12056)IFRAME,IPMIN,IPMAX
12056 FORMAT(" IFRAME=",I2,",IPMIN=",I2,",IPMAX=",I2,"LOGLOG")
      CALL TITLE(1H ,1,
     +"LITHIUM VELOCITY, M/S$",100,"MASS FLUX, AVERAGE,
     + @M)G/M(E)2(EX)/S$",100,6.,8.)
      CALL HEADIN("316 STAINLESS STEEL MASS LOSS$",100,3,2)
```

```
      CALL HEADIN("IN LIQUID LITHIUM$",100,3,2)
      CALL DFRAME
C     DETERMINE WHAT LOWEST FLUX IS, FOR GRAPH
      FLXLOW=.75*YDRAW4(3)
      CALL LOGLOG(.3,8.,FLXLOW,8.)
      CALL MARKER(9)
      CALL GRID(5,5)
      CALL CURVE(XDRAW1,YDRAW4,4,-1)
      DO 13012    IL=1,4
      YDRWW(IL,2,ILOGN)=EXP(B(2,1)+B(1,1)*ALOG(VEL(IL)))
13012 YDRAW4(IL)=EXP(B(2,1)+B(1,1)*ALOG(VEL(IL)))
      CALL CURVE (XDRAW1,YDRAW4,4,0)
      CALL MESSAG("SLOPE=$",100,4.,.9)
      CALL REALNO(B(1,1),3,"ABUT","ABUT")
      CALL MESSAG("COUPONS: $",100,4,.67)
      CALL INTNO(I0P1,"ABUT","ABUT")
      CALL MESSAG("-$",100,"ABUT","ABUT")
      CALL INTNO(IEP1,"ABUT","ABUT")
      CALL  MESSAG("PULLS $",100,4.,.45)
      CALL INTNO(IPMIN,"ABUT","ABUT")
      CALL MESSAG("-$",100,"ABUT","ABUT")
      CALL INTNO(IPMAX,"ABUT","ABUT")
      CALL MESSAG("TEMPS:$",100,4.,.2)
      CALL INTNO(IABS(IPTEM(1,IPULL)),"ABUT","ABUT")
      CALL MESSAG("-$",100,"ABUT","ABUT")
      CALL INTNO(IPTEM(2,IPULL),"ABUT","ABUT")
      CALL ENDPL(0)
1301  CONTINUE
      FLXLOW=1.E+10
      DO 1285 ILL=1,ILOGN
1285  IF(YDRWW(3,1,ILL).LT.FLXLOW)FLXLOW=YDRWW(3,1,ILL)
      IFRAME=IFRAME+1
      WRITE(9,12851)IFRAME
12851 FORMAT(" IFRAME=",I2,", ALL LOG-LOGS")
      CALL TITLE(1H ,1,
     +"LITHIUM VELOCITY, M/S$",100,"MASS FLUX, AVERAGE,
     + @M)G/M(E)2(EX)/S$",100,6.,8.)
      CALL HEADIN("316 STAINLESS STEEL MASS LOSS$",100,3,2)
      CALL HEADIN("IN LIQUID LITHIUM$",100,3,2)
      CALL DFRAME
      FLXLOW=FLXLOW*.75
      CALL LOGLOG(.3,8.,FLXLOW,6.)
      CALL MARKER(9)
      CALL GRID(5,5)
      DO 1286 ILL=1,ILOGN
      DO 1283 ILS=1,2
1283  CALL CURVE(XDRWW(1,ILL),YDRWW(1,ILS,ILL),4,(ILS-2))
      YTEMP=YPOSN(XDRWW(2,ILL),YDRWW(2,2,ILL))
      XTEMP=XPOSN(XDRWW(2,ILL),YDRWW(2,2,ILL))
      CALL INTNO(IPTEMM(1,ILL),XTEMP+.3,YTEMP-.05)
      CALL MESSAG("-$",100,"ABUT","ABUT")
      CALL INTNO(IPTEMM(2,ILL),"ABUT","ABUT")
      CALL MESSAG("C$",100,"ABUT","ABUT")
1286  CONTINUE
C
C     NEXT GROUP OF TIME INTERVALS (PULLS)
      IF(IAVV.EQ.0)IPULL=NB0+1
      IF(IAVV.EQ.0)GO TO 1302
      GO TO 11022
1291  FORMAT(17X,"FOR TEST SECT #",I1,", AVG SLOPE =",F6.4,"+",F5.4,
```

```
     +" UG/M2/S,COUP",I3,"-",I2," PULLS",I3,"-",I2,3X)
1292  CONTINUE
C
C
C*************************************************************************
C                                                                        *
C     PUT ROUTINE "OPTNGRAFS" HERE IF DESIRED                            *
C                                                                        *
C*************************************************************************
1600  CONTINUE
C     SPACING AT END OF FILE 7 ("OUTSUM")
      WRITE(7,1601)
1601  FORMAT("1")
C     FOR ALL PULLS, ALL COUPONS, WRITE SLOPES AND INTERCEPTS
      DO 1208 IP=1,NPULL
      WRITE(6,1207)IP,(INO(III),III=1,4)
1207  FORMAT(////17X,"PULL NUMBER ",I3,", SLOPES, INTERCEPTS,
     +(+STD DEV);:: NO OF POINTS",
     +/," N ",4(" SLOPE ",I1,",  INTERCEPT,POINTS  "))
      DO 1208 IN=1,16
1208  WRITE(6,1209)IN,((SLOPE(IS,IN,IP),SLSTD(IS,IN,IP),
     +CEPT(IS,IN,IP),CEPSTD(IS,IN,IP),NUSED(IS,IN,IP)),IS=1,4)
C      IF(IN.EQ.16.AND.IAVG.GT.0)WRITE (6,3558)I0P1,IEP1
1209  FORMAT(I3,2X,4(F5.3,"+",F5.3,1X,F5.3,"+",F5.3,"::",I1,3X))
      CALL DONEPL
      CALL PLOTE
9988  CALL QUIT(1)
      END
C
      SUBROUTINE TIMER(DATEIN,DATEOU,DAYS)
      INTEGER OMO,ODA,OYR
      REAL IHR
C     TAKE ACCOUNT OF MONTHS, DAYS,YEARS.
      IMO=DATEIN/10000.
      OMO=DATEOU/10000.
      IDA=(DATEIN-IMO*10000.)/100.
      ODA=(DATEOU-OMO*10000.)/100.
      IYR=DATEIN-IMO*10000.-IDA*100.
      OYR=DATEOU-OMO*10000.-ODA*100.
      IHR=(DATEIN-IMO*10000.-IDA*100.-IYR)*100./24.
      OHR=(DATEOU-OMO*10000.-ODA*100.-OYR)*100./24.
      EXTRA =0.
C     TAKE ACCOUNT OF VARYING LENGTH OF MONTHS
      M=IMO
C     REACHED LAST MONTH YET?
40    IF(M.EQ.OMO)GO TO 50
      M=M+1
C     NEW YEAR?
      IF(M.EQ.13)M=1
C     SOME MONTHS HAVE 1 DAY MORE THAN 30
      IF(M.EQ.1.OR.M.EQ.2.OR.M.EQ.6.OR.M.EQ.8
     +.OR.M.EQ.9.OR.M.EQ.11)EXTRA=EXTRA+1
C     FEBRUARY HAS 2 LESS DAYS, EXTRA IS 2 LESS
      IF(M.EQ.3)EXTRA=EXTRA-2.
      GO TO 40
50    DAYS=360.*(OYR-IYR)+30.*(OMO-IMO)+ODA-IDA+OHR-IHR+EXTRA
      RETURN
      END
```

```
C       TAKEN FROM MAIN PROGRAM MARCH 29,1980
C       DON BAUER UW MADISON NUC ENGR/CHEM ENGR
C       LITHIUM LOOP
C
C
C
1499    READ(5,1501)JXSIZ,JYSIZ,JSECT,((INCLUD(IJ,JJ),IJ=1,5),JJ=1,6)
C       READ OPTIONAL GRAPHING INSTRUCTIONS+
C       X AXIS AND Y AXIS SCALES, TEST SECTIONS, AND GROUPS OF COUPONS
C       JSECT ODD IMPLIES TEST SECTION #1
C       JSECT/2 ODD IMPLIES TEST SECTION #2
C       JSECT/4 ODD IMPLIES TEST SECTION #3
C       JSECT/8 ODD IMPLIES TEST SECTION #4
C       INCLUD(1,X) NEGATIVE DON'T DRAW POINTS, JUST LINES
C       INCLUD(1,X) POSITIVE DON'T DRAW LINES, JUST POINTS
C       INCLUD(1,X) ZERO DRAW POINTS AND LINES
C       INCLUD(2,X) FIRST PULL TO INCLUDEIN TRACE
C       INCLUD(3,X) LAST PULL TO INCLUDEIN TRACE
C       INCLUD(4,X) FIRST COUPON TO INCLUDE
C       INCLUD(5,X) LAST COUPON TO INCLUDE IN TRACE
1501    FORMAT(2(2X,I3),8X,I2,6(5I2))
1502    FORMAT(8(5I2))
        IF(JXSIZ.EQ.0)GO TO 1600
        IF(INCLUD(2,6).EQ.-1)READ(5,1502)((INCLUD(IJ,JJ),IJ=1,5),JJ=6,14)
C
C
        CALL NOBRDR
        CALL TITLE(1H ,1,"TIME, SECONDS * 10(E)-5(EX)$",
       +100,"MASS LOSS, G/M(E)2(EX)$",100,6.,8.)
        CALL HEADIN("316 STAINLESS STEEL MASS LOSS$",100,3,2)
        CALL HEADIN("IN LITHIUM$",100,3,2)
        XFULL=10.*JXSIZ
        XPART=2.*JXSIZ
        YPART=JYSIZ/5.
        YFULL=JYSIZ
        CALL GRAF(0.,XPART,XFULL,0.,YPART,YFULL)
        CALL DFRAME
        IFF(1)=0
        ICURVE=0
        IFF(2)=1
        IFF(3)=1
        IFF(4)=1
        IF((-1)**JSECT.LT.0)IFF(1)=1
        IF((-1)**(JSECT/2).NE.-1)IFF(2)=0
        IF((-1)**(JSECT/4).NE.-1)IFF(3)=0
        IF((-1)**(JSECT/8).NE.-1)IFF(4)=0
        YDIS=2.
        XDIS=3.
        CALL RESET("COMPLX")
        CALL MESSAG("LINES ARE $",100,XDIS,YDIS)
        IF(IFF(1).NE.0)YDIS=YDIS-.2
        IF(IFF(1).NE.0)CALL MESSAG("SOLID     V=1.36M/S$",100,XDIS,YDIS)
        IF(IFF(4).NE.0)YDIS=YDIS-.2
        IF(IFF(4).NE.0)CALL MESSAG("CHAINDASH V= .96M/S$",100,XDIS,YDIS)
        IF(IFF(2).NE.0)YDIS=YDIS-.2
        IF(IFF(2).NE.0)CALL MESSAG("DOT-DASH  V= .65M/S$",100,XDIS,YDIS)
        IF(IFF(3).NE.0)YDIS=YDIS-.2
        IF(IFF(3).NE.0)CALL MESSAG("DOTTED    V= .45M/S$",100,XDIS,YDIS)
C
C
```

```
C     GRAPH WILL STATE COUPON LIMITS FOR FIRST GROUP ONLY
      IF(ICURVE.NE.0)GO TO 1550
      YDIS=YDIS-.3
      CALL MESSAG("COUPONS$",100,XDIS,YDIS)
      INC4=INCLUD(4,1)
      INC5=INCLUD(5,1)
      CALL INTNO(INC4,"ABUT","ABUT")
      CALL MESSAG(",$",100,"ABUT","ABUT")
      CALL INTNO(INC5,"ABUT","ABUT")
C
 1550 DO 1590 IS=1,4
      IF(IFF(IS).EQ.0)GO TO 1590
      IF(IS.EQ.2)CALL CHNDOT
      IF(IS.EQ.3)CALL DOT
      IF(IS.EQ.4)CALL CHNDSH
      DO 1580 IINC=1,15
      IF(INCLUD(2,IINC).EQ.0)GO TO 1580
      DO 1570 IN=INCLUD(4,IINC),INCLUD(5,IINC)
      ICOUNT=0
      IF(IN.GT.INCLUD(4,IINC).OR.(ICURVE.NE.0))GO TO 1555
      YDIS=YDIS-.3
C
C
      CALL MESSAG("PULLS$",100,XDIS,YDIS)
      INC2=INCLUD(2,IINC)
      INC3=INCLUD(3,IINC)
      CALL INTNO(INC2,"ABUT","ABUT")
      CALL MESSAG(",$",100,"ABUT","ABUT")
      CALL INTNO(INC3,"ABUT","ABUT")
 1555 CALL MARKER(IN)
      DO 1560 IP=INCLUD(2,IINC),INCLUD(3,IINC)
      ICOUNT=ICOUNT+1
C     GRAPH THE COUPONS "IN" FOR THE PULLS "IP"
      XDRAW1(ICOUNT)=ABS(TIM(IS,IN,IP))*.864
      YDRAW1(ICOUNT)=CUM(IS,IN,IP)/.491
 1560   YDRAW2(ICOUNT)=(CEPT(IS,IN,IP)+SLOPE(IS,IN,IP)*.864*ABS
     +(TIM(IS,IN,IP)))
      IF(INCLUD(1,IINC).GE.0)CALL CURVE(XDRAW1,YDRAW1,ICOUNT,-1)
 1570   IF(INCLUD(1,IINC).LE.0)CALL CURVE(XDRAW1,YDRAW2,ICOUNT,0)
 1580       CONTINUE
      ICURVE=ICURVE+1
 1590   CONTINUE
C
      CALL RESET("CHNDSH")
      CALL ENDPL
      GO TO 1499
 1600 CONTINUE
```

```
1    2018P060R10R250C14C01*06A01S00+00Z05E
2    1.        0.        280.      0.        30.
3    092078.12 101278.12 092078.12 101278.12 092078.12 100978.12 092078.12 100978.12
4    440 255FIRST PULL 450-255 CONDITIONS.  3 WEEK SHAKEDOWN BEFORE STARTING TIMER.
5    102078.12 110878.12 102078.12 110878.12 102078.12 110878.12 102078.12 110878.12
6    440 255 SECOND PULL 450-255 CONDITIONS.
7    111878.18 121178.12 111878.18 121178.12 111878.18 121178.12 111878.18 121178.12
8    440 255CONTINUING 450-255 CONDITIONS.
9    121878.12 011679.12 121878.12 011679.12 121878.12 011679.12 121878.12 011679.12
10   440 255 CONTINUING 450-255 CONDITIONS.
11   011879.18 030879.12 011879.18 030879.12 011879.18 030879.12 011879.18 030879.12
12   440 255LAST PULL FOR 136, 65CMS COUPONS. CONTINUING 450-255 CONDITIONS.
13   031079.12 032179.08 031079.12 032179.08 031079.12 032179.08 031079.12 032179.08
14   440 255FIRST PULL FOR 136CMS AND (DIFF.MATL) 65CMS. 450-255 CONDITIONS.
15   032379.08 041179.12 032379.08 041179.12 032379.08 041179.12 032379.08 041179.12
16   440 255CONTINUING AT 450-255 CONDITIONS.
17   041279.18 050179.09 041279.18 050179.09 041279.18 050179.09 041279.18 050179.09
18   440 255LAST PULL FOR 450-255 CONDITIONS.
19   050379.08 052979.10 050379.08 052979.10 050379.08 052979.10 050379.08 052979.10
20   440 340FIRST PULL 450-340 CONDITIONS. SAME COUPONS.
21   053079.18 072479.10 053079.18 072479.10 053079.18 072479.10 053079.18 072479.10
22   440 340SECOND PULL 450-340 CONDITIONS.
23   073179.18 092779.12 073179.18 092779.12 073179.18 092779.12 073179.18 092779.12
24   440 340LAST PULL 450-340 CONDITIONS.  LAST PULL THESE COUPONS.
25   100179.20 100279.14 100179.20 100279.14 100179.20 100279.14 100179.20 100279.14
26    490 325FIRST PULL 500-325 CONDITIONS. FRESH COUPONS. TOTAL 18 HRS.
27   100379.19 100479.13 100379.19 100479.13 100379.19 100479.13 100379.19 100479.13
28    490 325CONTINUING 500-325 CONDITIONS. TOTAL 36 HRS.
29   101079.20 101279.10 101079.20 101279.10 101079.20 101279.10 101079.20 101279.10
30    490 325CONTINUING 500-325 CONDITIONS. TOTAL 74 HRS.
31   101979.20 102479.09 101979.20 102479.09 101979.20 102479.09 101979.20 102479.09
32    490 325CONTINUING 500-325 CONDITIONS. COUPONS IN FOR 4.5 DAYS THIS TIME.
33   102779.15 102979.08 102779.15 102979.08 102779.15 102979.08 102779.15 102979.08
34    490 325TWO MORE DAYS AT 500-325. CHECKING EFFECT OF INTERVAL
35   103079.20 111679.09 103079.20 111679.09 103079.20 111679.09 103079.20 111679.09
36    490 325TWO WEEKS MORE AT 500-325....
37   121079.18 010780.09 121079.18 010780.09 121079.18 010780.09 121079.18 010780.09
38    490 325ALMOST FOUR WEEKS MORE AT 500-325 NOMINAL TEMPERATURES
39   010880.19 022680.09 010880.19 022680.09 010880.19 022680.09 010880.19 022680.09
40    490 325 SEVEN MORE WEEKS 500-325
41   022880.17 032080.09 022880.17 032080.09 022880.17 032080.09 022880.17 032080.09
42    490 325 THREE MORE WEEKS AT 500-325 NOMINAL(PULL 3/19;LEAP YEAR SO SAY 3/20)
43   4.056280  4.058109  4.058618  3.990729  3.996513  4.049694  3.995451  4.055821
44   4.052291  4.053676  4.064659  4.062181  4.033479  3.995588  4.052285  4.042658
45   4.049656  4.051806  4.052945  3.982392  3.989056  4.044441  3.987278  4.050190
46   4.046860  4.048040  4.059444  4.056629  4.027435  3.986183  4.046330  4.036729
47                                                                       4.027277
48   4.047404  4.049849  4.051085  3.980142  3.986970  4.043025  3.984095  4.048655
49   4.045406  4.047304  4.058060  4.055169  4.025700  3.983616  4.044620  4.019469
50                                                             4.032034
51   4.044233  4.046924  4.048521  3.976979  3.983982  4.040433  3.961442  4.045871
52   4.042335  4.044065  4.055749  4.052741  4.022706  3.979855  4.024526  4.015015
53                                                   4.039877
54   4.040146  4.042747  4.045071  3.973158  3.980529  4.036834  3.976196  4.041932
55   4.039060  4.041000  4.052670  4.049337  4.018264  4.031610  4.018702  4.010520
56                                         4.045195
57   4.033190  4.035965  4.039436  3.967472  3.975080  4.030990  3.968659  4.034806
58   4.033310  4.035870  4.047125  4.042790  4.032910  4.022786  4.009917  4.003486
59
60   4.065535  4.055485  4.053114  4.044325  4.031182  4.049306  4.040734  4.062266
```

WEIGHT LOSS DATA INPUT FILE--IDENTIFICATION LINES 1-42
COUPON SET #1 LINES 43...

61	4.050631	4.047073	4.042568	4.058963	4.055710	4.052190	4:054590	4.060545	
62	4.058854	4.048655	4.046511	4.038540	4.025376	4.043900	4.034685	4.055973	TS1
63	4.024978	4.041465	4.037386	4.053567	4.049684	4.046043	4.048189	4.054470	
64								4.043195	TS1
65	4.055990	4.046189	4.044247	4.036104	4.023157	4.041660	4.032447	4.053719	
66	4.022818	4.039033	4.035034	4.051256	4.047264	4.043526	4.045394	4.036072	
67							4.046392		
68	4.050691	4.040665	4.038761	4.030942	4.018692	4.037405	4.026973	4.048458	
69	4.017244	4.033800	4.030522	4.045996	4.040200	4.035648	4.032415	4.027969	
70						4.030746			
71	4.040635	4.038818	4.037925	4.029128	4.016966	4.035715	4.025215	4.046782	
72	4.015440	4.031990	4.028816	4.044285	4.038300	4.018404	4.030249	4.025954	
73					4.043362				
74	4.045455	4.036063	4.034475	4.026669	4.014510	4.033362	4.022656	4.044244	
75	4.013026	4.029723	4.026617	4.041936	4.032574	4.009956	4.027128	4.023548	
76				4.045148					
77	4.044651	4.035780	4.033638	4.025804	4.013614	4.032460	4.021729	4.043273	
78	4.011982	4.028600	4.025598	4.038668	4.028240	4.006547	4.025940	4.022162	
79	3.954736	3.984600	3.983305	3.982110	3.982600	3.973775	4.006980	3.981500	
80	3.983946	3.986041	3.980047	3.978976	4.009766	3.992393	4.006667	3.979718	
81	3.952727	3.982402	3.981065	3.979864	3.980401	3.971651	4.004889	3.979325	
82	3.981772	3.984752	3.978946	3.977216	4.007762	3.990425	4.004536	3.977596	
83	-2.								TS1
84	3.951464	3.981256	3.979736	3.978591	3.978971	3.970382	4.003620	3.977940	
85	3.980404	3.983088	3.977258	3.975304	4.006057	3.988649	4.002905	3.975945	
86	-2.								
87	3.949174	3.978994	3.977346	3.976174	3.976383	3.968093	4.001171	3.975616	
88	3.978377	3.980985	3.975116	3.973115	4.004217	3.966535	4.000991	3.973974	
89	-2.								
90	3.947016	3.976795	3.975235	3.974054	3.974262	3.966098	3.998981	3.973555	
91	3.976284	3.979076	3.973059	3.971013	4.002288	3.984605	3.999080	3.971876	
92	-2.								
93	3.945468	3.975511	3.973874	3.972800	3.972951	3.964786	3.997640	3.972000	
94	3.975069	3.977946	3.971965	3.969759	4.000959	3.983411	3.997667	3.970295	
95	-2.								
96	3.942619	3.972723	3.970985	3.969825	3.969888	3.961620	3.994090	3.968452	
97	3.971539	3.974303	3.968174	3.965765	3.996697	3.978945	3.993196	3.966091	
98	-2.								
99	3.924214	3.955391	3.954329	3.953181	3.954191	3.944895	3.975739	3.950173	
100	3.952741	3.956396	3.952043	3.946973	3.977767	3.959358	3.974357	3.947050	
101								4.013940	
102	3.921615	3.952881	3.951764	3.950645	3.951540	3.942190	3.973025	3.947514	
103	3.950172	3.953754	3.949493	3.944356	3.975059	3.956700	3.971700	4.009724	
104	-2.								
105	3.919472	3.950893	3.949680	3.948633	3.949525	3.940271	3.971163	3.945715	
106	3.948365	3.952047	3.947930	3.942741	3.973389	3.954974	3.970002	4.007781	
107	-2.								
108	4.055429	3.990858	4.038879	4.043704	4.041589	4.052517	4.032737	4.062281	TS2
109	4.050418	3.996005	4.067083	4.055710	4.037949	4.070165	4.062049	4.039492	
110	4.050237	3.983620	4.034260	4.038967	4.036839	4.047956	4.028138	4.057625	TS2
111	4.045735	3.989636	4.063145	4.051966	4.034090	4.065468	4.057030	4.034958	
112								4.047190	
113	4.049184	3.982102	4.033244	4.037796	4.035763	4.046874	4.027056	4.056740	
114	4.044795	3.988206	4.062225	4.051053	4.033246	4.064492	4.055948	4.041926	
115							4.061960		
116	4.047394	3.980109	4.031714	4.036244	4.034165	4.045302	4.025860	4.055469	
117	4.043504	3.986672	4.060878	4.049668	4.032015	4.063115	4.057190	4.039536	
118						4.055573			
119	4.044704	3.977184	4.029194	4.033541	4.031593	4.042821	4.023158	4.052800	
120	4.040110	3.983051	4.058179	4.046885	4.029391	4.049923	4.054161	4.036538	

WEIGHT LOSS DATA INPUT FILE--COUPON SETS 1, 2...
LINES 61-107; 108...

121					4.033333			
122	4.040135	3.972525	4.024459	4.029147	4.027123	4.038440	4.018794	4.048854
123	4.036625	3.979129	4.054167	4.042710	4.025466	4.044390	4.048726	4.032674
124								
125	4.002354	4.001656	3.994200	3.997982	3.991851	3.990131	3.988985	3.999375
126	3.995451	3.987806	3.991881	4.031454	4.003937	4.003673	4.003550	4.000982
127	3.995873	3.995204	3.988010	3.991904	3.985950	3.984536	3.983345	3.993554
128	3.989300	3.981739	3.985375	4.027200	3.997375	3.997356	3.997246	3.994978
129								4.049626
130	3.993142	3.992817	3.985395	3.989090	3.982982	3.981397	3.980369	3.990661
131	3.986755	3.979135	3.983109	4.025414	3.994894	3.994774	3.994575	4.043704
132							4.048050	
133	3.988315	3.988608	3.981390	3.985056	3.978935	3.976858	3.975950	3.986416
134	3.982424	3.974894	3.979120	4.022241	3.989385	3.989664	4.038981	4.039489
135						4.043487		
136	3.987255	3.987834	3.980565	3.984179	3.978052	3.975920	3.975014	3.985631
137	3.981694	3.974205	3.978504	4.021508	3.988857	4.033365	4.038476	4.039390
138					4.057284			
139	3.984934	3.985784	3.978512	3.982039	3.975755	3.973615	3.972584	3.983192
140	3.979351	3.971920	3.976081	4.018664	4.048092	4.025090	4.034576	4.036472
141				4.057429				
142	3.984822	3.985882	3.978569	3.982040	3.975765	3.973556	3.972520	3.983148
143	3.979310	3.971914	3.976325	4.052581	4.045160	4.023500	4.034591	4.036519
144								
145	3.928997	3.991745	3.982787	4.007411	4.003080	4.004150	3.985295	4.010037
146	4.011541	3.985814	3.986662	3.986118	3.995292	4.005603	3.969859	3.988722
147	3.927189	3.990096	3.981292	4.005900	4.001282	4.002560	3.983875	4.009771
148	4.010281	3.984479	3.984963	3.984550	3.993534	4.003800	3.968006	3.987142
149	-2.							
150	3.925666	3.988429	3.979729	4.004392	3.999711	4.001100	3.982364	4.007290
151	4.008545	3.982447	3.983402	3.983004	3.991773	4.002239	3.966377	3.985529
152	-2.							
153	3.923765	3.986467	3.977649	4.002304	3.997743	3.999010	3.980231	4.005239
154	4.006555	3.980733	3.981330	3.980851	3.989875	4.000418	3.964516	3.983669
155	-2.							
156	3.922019	3.984549	3.975640	4.000268	3.995689	3.996987	3.978117	4.003134
157	4.004666	3.978809	3.979702	3.978935	3.988274	3.998779	3.963030	3.982125
158	-2.							
159	3.920931	3.983569	3.974671	3.999234	3.994785	3.996020	3.977126	4.002197
160	4.003614	3.977778	3.978757	3.977934	3.987312	3.997893	3.962218	3.981196
161	-2.							
162	3.919682	3.982520	3.973752	3.998278	3.993863	3.995071	3.975839	4.000748
163	4.001943	3.975607	3.975866	3.974552	3.983824	3.994090	3.958504	3.977838
164	-2.							
165	3.905233	3.968572	3.960714	3.984020	3.970975	3.990973	3.961242	3.998220
166	3.989925	3.964159	3.964602	3.962300	3.970155	3.981185	3.945489	3.964605
167								3.979610
168	3.903643	3.966846	3.958721	3.981925	3.976985	3.978877	3.958982	3.985995
169	3.987754	3.961943	3.962460	3.960112	3.967958	3.979029	3.943245	3.974690
170	-2.							
171	3.902732	3.965978	3.957625	3.980795	3.976084	3.977951	3.957935	3.985036
172	3.986719	3.960912	3.961455	3.959077	3.966973	3.979145	3.942376	3.972874
173	-2.							
174	4.051815	4.042631	4.054110	4.058357	4.058588	4.038479	4.051724	4.058866
175	4.037547	4.053832	4.044475	4.054744	4.042829	4.049130	4.068081	4.057295
176	4.046615	4.037677	4.049642	4.054138	4.054667	4.034618	4.047102	4.054995
177	4.033347	4.049956	4.040852	4.051242	4.039131	4.045360	4.064449	4.053635
178								4.042738
179	4.044959	4.036157	4.048312	4.052876	4.053329	4.033248	4.045896	4.053853
180	4.032115	4.048789	4.039685	4.050129	4.038009	4.044216	4.063307	4.039115

WEIGHT LOSS DATA INPUT FILE -- COUPON SETS 2, 3...
LINES 120-173; 174-...

181							4.041218		
182	4.043081	4.034505	4.046871	4.051446	4.051800	4.031654	4.044509	4.052504	
183	4.030737	4.047513	4.038365	4.048858	4.036660	4.042942	4.037106	4.036890	
184						4.038344			
185	4.040371	4.031995	4.044727	4.049359	4.049554	4.029633	4.042849	4.050694	
186	4.028694	4.045610	4.036684	4.047000	4.034872	4.033515	4.034495	4.034734	
187					4.051985				
188	4.035167	4.027516	4.040738	4.045478	4.045833	4.025765	4.039065	4.047210	
189	4.024990	4.042094	4.033348	4.043454	4.045829	4.028927	4.030465	4.037030	
190				4.035072					
191	4.034347	4.026779	4.040187	4.044925	4.045365	4.025300	4.038585	4.046664	
192	4.024415	4.041595	4.032837	4.031585	4.044331	4.028359	4.029890	4.030238	
193			4.057054						
194	4.033464	4.025921	4.039529	4.044217	4.044648	4.024555	4.037876	4.045961	
195	4.023740	4.040905	4.052156	4.029264	4.043392	4.027474	4.029045	4.029486	
196		4.049206							
197	4.030796	4.023346	4.037511	4.042406	4.042795	4.022585	4.035389	4.044124	
198	4.021900	4.040685	4.047860	4.025786	4.041160	4.025182	4.027130	4.027424	
199	4.042416								TS3
200	4.029351	4.021994	4.036325	4.041358	4.041510	4.021279	4.034741	4.042935	
201	4.033230	4.038835	4.046368	4.024495	4.039631	4.023890	4.026040	4.026439	
202								-4.041081	TS
203	4.026922	4.019814	4.034373	4.039573	4.039550	4.019204	4.032807	4.032656	
204	4.027045	4.035887	4.043904	4.022103	4.037100	4.021860	4.024086	4.024654	
205							-4.049903		
206	4.026132	4.019104	4.033805	4.039014	4.038065	4.018492	4.044617	4.029351	
207	4.024489	4.035005	4.043326	4.021400	4.036225	4.021146	4.023480	4.024149	
208									
209	3.940065	3.982648	3.991519	4.004592	4.000418	3.989539	3.982367	3.97127	
210	4.006733	3.979164	4.002360	3.978071	3.984761	3.967687	3.986958	4.006575	
211	3.937900	3.980790	3.999792	4.003096	3.998908	3.987005	3.980845	3.969755	
212	4.005490	3.978007	4.001079	3.976738	3.983094	3.965944	3.985250	4.005029	
213	-2.								
214	3.936378	3.979390	3.989201	4.001695	3.997639	3.985664	3.979495	3.968427	
215	4.004162	3.976847	3.999817	3.975510	3.981838	3.964638	3.984026	4.003817	
216	-2.								
217	3.934313	3.977435	3.986204	3.999505	3.995465	3.983644	3.977493	3.966200	
218	4.002094	3.974882	3.997596	3.973262	3.979589	3.962366	3.981781	4.001845	
219	-2.								
220	3.932614	3.975891	3.984667	3.997734	3.993547	3.981792	3.975650	3.964292	
221	3.999984	3.972905	3.995586	3.971184	3.977594	3.960619	3.980054	4.000090	
222	-2.								
223	3.931177	3.974867	3.983647	3.996706	3.992506	3.980581	3.974412	3.962565	
224	3.998551	3.971057	3.993611	3.969319	3.975735	3.959253	3.978956	3.999246	
225	-2.								
226	3.929246	3.972348	3.981207	3.994212	3.989665	3.977502	3.970941	3.958679	
227	3.994284	3.966180	3.988558	3.965056	3.971296	3.955846	3.975906	3.996029	
228	-2.								
229	3.913212	3.958606	3.969110	3.982323	3.978165	3.965756	3.959324	3.947170	
230	3.983372	3.955548	3.977937	3.954903	3.960085	3.944700	3.966241	3.985885	
231								3.992908	
232	3.911715	3.957241	3.967717	3.980702	3.976475	3.963904	3.957451	3.945304	
233	3.981320	3.953413	3.975728	3.952904	3.958104	3.943093	3.964611	3.987619	
234	-2.								
235	3.910971	3.956580	3.967040	3.979930	3.975720	3.963088	3.956611	3.944479	
236	3.980479	3.952573	3.974869	3.952093	3.957325	3.942410	3.963981	3.986052	
237	-2.								
238	4.047618	4.042749	4.054395	4.061979	4.043844	4.053368	4.051249	4.051815	TS3
239	4.056752	4.050071	4.062614	4.060050	4.054415	4.065784	4.049646	4.064834	
240	4.042205	4.037847	4.049960	4.057332	4.039380	4.049316	4.047098	4.047536	

WEIGHT LOSS DATA INPUT FILE -- COUPON SETS 3; 4...
LINES 181-237; 238...

241	4.052511	4.045570	4.058295	4.055897	4.050165	4.061239	4.043920	4.259980
242								4.045287
243	4.039179	4.034607	4.047546	4.054880	4.037131	4.047180	4.045015	4.045409
244	4.050479	4.043413	4.056059	4.053655	4.047964	4.058910	4.041465	4.040035
245							4.038414	
246	4.036670	4.031550	4.045362	4.052570	4.035042	4.045250	4.043000	4.043451
247	4.048473	4.041207	4.053977	4.051690	4.045800	4.056953	4.032585	4.036821
248						4.044415		
249	4.033035	4.027389	4.042064	4.049177	4.031985	4.042442	4.040065	4.040802
250	4.045806	4.038082	4.050988	4.048718	4.042597	4.037664	4.028310	4.033145
251					4.037707			
252	4.027726	4.021353	4.037306	4.043970	4.027271	4.037481	4.035394	4.036290
253	4.041507	4.033540	4.045985	4.043445	4.028232	4.030938	4.021639	4.027148
254				4.039425				
255	4.026695	4.020230	4.036430	4.043092	4.026449	4.036631	4.034480	4.035384
256	4.040532	4.032713	4.045120	4.034246	4.027201	4.029806	4.020570	4.026097
257			4.032274					
258	4.025876	4.019087	4.035596	4.042257	4.025707	4.035905	4.033766	4.034713
259	4.039904	4.031975	4.025419	4.032357	4.026126	4.028872	4.019694	4.025494
260		4.057269						
261	4.022566	4.014949	4.033045	4.039555	4.023040	4.033470	4.031300	4.032270
262	4.037652	4.048036	4.020625	4.027910	4.022690	4.025590	4.016006	4.022649
263	4.046985							
264	4.020322	4.012714	4.031232	4.037561	4.021387	4.031708	4.029601	4.030356
265	4.036539	4.045530	4.018522	4.026045	4.020490	4.023630	4.014040	4.021070
266								-4.047830
267	4.017716	4.010039	4.029044	4.035260	4.019179	4.029567	4.027593	4.038000
268	4.029754	4.041926	4.015843	4.023429	4.017817	4.021228	4.011745	4.018733
269							-4.050256	
270	4.017113	4.009705	4.028595	4.034811	4.018795	4.029149	4.044409	4.034756
271	4.027526	4.041532	4.015683	4.023315	4.017432	4.021040	4.011621	4.018548
272								
273	3.978600	3.983229	3.996423	3.983851	3.981344	4.004552	3.970566	3.975786
274	4.011551	3.998932	3.985386	3.993072	4.003184	3.968137	3.990154	3.988146
275	3.976262	3.981105	3.994425	3.981675	3.979331	4.002746	3.968505	3.974016
276	4.009785	3.996758	3.983366	3.991277	4.001150	3.965964	3.987783	3.885918
277	-2.							
278	3.974915	3.979719	3.993108	3.980342	3.977951	4.001346	3.967222	3.972706
279	4.008486	3.995390	3.981971	3.989929	3.999632	3.964448	3.986272	3.884476
280	-2.							
281	3.972671	3.977416	3.990890	3.977996	3.975647	3.999109	3.965070	3.970475
282	4.006350	3.993311	3.979704	3.987804	3.997303	3.962545	3.984463	3.882661
283	-2.							
284	3.970716	3.975389	3.988865	3.976045	3.973754	3.997230	3.962919	3.968408
285	4.004316	3.991453	3.977589	3.985703	3.995277	3.960790	3.982705	3.880874
286	-2.							
287	3.968729	3.973546	3.987223	3.974210	3.972321	3.996011	3.961487	3.966961
288	4.003160	3.990160	3.976194	3.984415	3.993904	3.959314	3.981392	3.879708
289	-2.							
290	3.965246	3.970135	3.984041	3.970880	3.969243	3.992977	3.958166	3.963830
291	4.000249	3.987025	3.972967	3.981124	3.990707	3.956248	3.978281	3.877094
292	-2.							
293	3.948278	3.953246	3.970248	3.955566	3.955094	3.980143	3.945119	3.951199
294	3.988050	3.974265	3.959588	3.967751	3.976174	3.939388	3.960837	3.861205
295								3.989071
296	3.945752	3.950884	3.967785	3.952945	3.952494	3.977534	3.942605	3.948745
297	3.985516	3.971925	3.957250	3.965375	3.973864	3.937110	3.958586	3.984320
298	-2.							
299	3.943874	3.949204	3.966198	3.951275	3.950894	3.975900	3.941077	3.947285
300	3.984109	3.970589	3.955931	3.963968	3.972561	3.935851	3.957411	3.982118

WEIGHT LOSS DATA INPUT FILE -- COUPON SET 4..
LINES 241-301

```
301   -2.
302   0120        00000004000100000400000000000 0.00000 +0.0000 300.000 0.00000 100.000 GRAPH
303   0000
304   0108        00000004000100000000000000000 0.00000 0.00000 300.000 0.00000 100.000
305   1220        00000004000100000000000000000 0.00000 0.00000 300.000 0.00000 100.000
306   0000
307   0000
308   0911        00000004000100000000000000000 0.00000 0.00000 300.000 0.00000 80.0000
309   1219        00000004000100000000000000000 0.00000 0.00000  100.00 0.00000 100.000
310   1419        00000004000100000000000000000 0.00000 0.00000  100.00 0.00000 100.000
311   000000000000000000000000000000000
312   0000
313   X=006Y=070        J=0101121801080001030108
314   X=006Y=070        J=0101121809160001030916
315   X=006Y=070        J=0201121801080001030108
316   X=006Y=070        J=0201121809160001030916
317   X=006Y=070        J=0401121801080001030108
318   X=006Y=070        J=0401121809160001030916
319   X=006Y=070        J=0801121801080001030108
320   X=006Y=070        J=0801121809160001030916
321   00000  000
322   X=006Y=070        J=1501121801060001020106
323   00000000000
324
```

WEIGHT LOSS DATA INPUT FILE--GRAPHING INSTRUCTIONS

LINE 302; 0120 MEANS GRAPH PULLS 1 THROUGH 20.

4 in column 18 means force break in least squares at pull 8, (where temperature difference was changed)

4 in column 28 means force break at pull 18 (obvious change in rate)

1 in column 22 means do not draw line through data following pull 12 (up to break) since this is transient

TEST PERIOD # 1
FIRST PULL 450-255 CONDITIONS. 3 WEEK SHAKEDOWN BEFORE STARTING TIM
MAX TEMP 440C -- MIN TEMP 255C
START DATES AND ANY FRESH COUPONS ARE:

	92078.12	92078.12	92078.12	92078.12
# 1	4.056280	4.055429	4.051815	4.047618
# 2	4.058109	3.990858	4.042631	4.042749
# 3	4.058618	4.038879	4.054110	4.054395
# 4	3.990729	4.043704	4.058357	4.061979
# 5	3.996613	4.041589	4.058588	4.043844
# 6	4.049694	4.052517	4.038479	4.053388
# 7	3.995451	4.032737	4.051724	4.051249
# 8	4.055821	4.062281	4.058886	4.051815
# 9	4.052291	4.050418	4.037547	4.056752
#10	4.053676	3.996005	4.053832	4.050071
#11	4.064659	4.067083	4.044475	4.062614
#12	4.062181	4.055710	4.054744	4.060050
#13	4.033479	4.037949	4.042829	4.054415
#14	3.995588	4.070165	4.049130	4.065784
#15	4.052285	4.062049	4.068081	4.048646
#16	4.042658	4.039492	4.057205	4.064834

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

	101278.12	101278.12	100978.12	100978.12
# 1	4.049656	4.050237	4.046615	4.042205
# 2	4.051806	3.983620	4.037677	4.037847
# 3	4.052945	4.034260	4.049642	4.049960
# 4	3.982392	4.038967	4.054138	4.057332
# 5	3.989056	4.036839	4.054667	4.039380
# 6	4.044441	4.047956	4.034618	4.049316
# 7	3.987278	4.028138	4.047102	4.047098
# 8	4.050190	4.057625	4.054995	4.047536
# 9	4.046860	4.045735	4.033347	4.052511
#10	4.048840	3.989636	4.049956	4.045570
#11	4.059444	4.063145	4.040852	4.058295
#12	4.056629	4.051966	4.051242	4.055897
#13	4.027435	4.034090	4.039131	4.050165
#14	3.986183	4.065468	4.045360	4.061239
#15	4.046330	4.057030	4.064449	4.043920
#16	4.036729	4.034958	4.053635	4.059980

TEST PERIOD # 2
SECOND PULL 450-255 CONDITIONS.
MAX TEMP 440C -- MIN TEMP 255C
START DATES AND ANY FRESH COUPONS ARE:

	102078.12	102078.12	102078.12	102078.12
#16	4.027277	4.047190	4.042738	4.045287

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

	110878.12	110878.12	110878.12	110878.12
# 1	4.047494	4.049184	4.044959	4.039179
# 2	4.049849	3.982102	4.036157	4.034607
# 3	4.051085	4.033244	4.048312	4.047546
# 4	3.980142	4.037796	4.052876	4.054888
# 5	3.986970	4.035763	4.053329	4.037131
# 6	4.043025	4.046874	4.033248	4.047180
# 7	3.984895	4.027056	4.045896	4.045015
# 8	4.048655	4.056740	4.053853	4.045409
# 9	4.045406	4.044795	4.032115	4.050479
#10	4.047384	3.988206	4.048789	4.043413
#11	4.058060	4.062225	4.039685	4.056059
#12	4.055169	4.051053	4.050129	4.053655
#13	4.025700	4.033246	4.038009	4.047964
#14	3.983616	4.064492	4.044216	4.058910
#15	4.044620	4.055948	4.063307	4.041465
#16	4.019469	4.041926	4.039115	4.040035

TEST PERIOD # 3
CONTINUING 450-255 CONDITIONS.
MAX TEMP 440C -- MIN TEMP 255C
START DATES AND ANY FRESH COUPONS ARE:

111879.18	111879.18	111878.18	111878.18
#15 4.032034	#15 4.061960	#15 4.041218	#15 4.038414

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

121178.12	121178.12	121178.12	121178.12
# 1 4.044233	# 1 4.047394	# 1 4.043081	# 1 4.036670
# 2 4.046924	# 2 3.980109	# 2 4.034505	# 2 4.031550
# 3 4.048521	# 3 4.031714	# 3 4.046871	# 3 4.045362
# 4 3.976979	# 4 4.036244	# 4 4.051446	# 4 4.052570
# 5 3.983982	# 5 4.034165	# 5 4.051800	# 5 4.035042
# 6 4.040433	# 6 4.045302	# 6 4.031654	# 6 4.045250
# 7 3.981442	# 7 4.025860	# 7 4.044509	# 7 4.043000
# 8 4.045871	# 8 4.055469	# 8 4.052504	# 8 4.043451
# 9 4.042335	# 9 4.043504	# 9 4.030737	# 9 4.048473
#10 4.044065	#10 3.986672	#10 4.047513	#10 4.041207
#11 4.055749	#11 4.060878	#11 4.038365	#11 4.053977
#12 4.052741	#12 4.049668	#12 4.048858	#12 4.051690
#13 4.022706	#13 4.032015	#13 4.036660	#13 4.045800
#14 3.979855	#14 4.063115	#14 4.042942	#14 4.056953
#15 4.024526	#15 4.057190	#15 4.037106	#15 4.032585
#16 4.015015	#16 4.039536	#16 4.036890	#16 4.036821

TEST PERIOD # 4
CONTINUING 450-255 CONDITIONS.
MAX TEMP 440C -- MIN TEMP 255C
START DATES AND ANY FRESH COUPONS ARE:

121878.12	121878.12	121878.12	121878.12
#14 4.039877	#14 4.055573	#14 4.038344	#14 4.044415

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

11679.12	11679.12	11679.12	11679.12
# 1 4.040146	# 1 4.044704	# 1 4.040371	# 1 4.033035
# 2 4.042747	# 2 3.977184	# 2 4.031995	# 2 4.027389
# 3 4.045071	# 3 4.029194	# 3 4.044727	# 3 4.042064
# 4 3.973158	# 4 4.033541	# 4 4.049359	# 4 4.049177
# 5 3.980529	# 5 4.031593	# 5 4.049554	# 5 4.031985
# 6 4.036834	# 6 4.042821	# 6 4.029633	# 6 4.042442
# 7 3.976196	# 7 4.023158	# 7 4.042849	# 7 4.040065
# 8 4.041932	# 8 4.052900	# 8 4.050694	# 8 4.040802
# 9 4.039060	# 9 4.040110	# 9 4.028694	# 9 4.045806
#10 4.041000	#10 3.983051	#10 4.045610	#10 4.038082
#11 4.052670	#11 4.058179	#11 4.036684	#11 4.050988
#12 4.049337	#12 4.046885	#12 4.047000	#12 4.048718
#13 4.018264	#13 4.029391	#13 4.034872	#13 4.042597
#14 4.031610	#14 4.049923	#14 4.033515	#14 4.037664
#15 4.018702	#15 4.054161	#15 4.034495	#15 4.028310
#16 4.010520	#16 4.036538	#16 4.034734	#16 4.033145

TEST PERIOD # 5
LAST PULL FOR 136, 65CMS COUPONS. CONTINUING 450-255 CONDITIONS.
MAX TEMP 440C -- MIN TEMP 255C
START DATES AND ANY FRESH COUPONS ARE:

11879.18	11879.18	11879.18	11879.18
#13 4.045195	#13 4.033333	#13 4.051985	#13 4.037707

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

30879.12	30879.12	30879.12	30879.12
# 1 4.033190	# 1 4.040135	# 1 4.035167	# 1 4.027726
# 2 4.035965	# 2 3.972525	# 2 4.027516	# 2 4.021353
# 3 4.039436	# 3 4.024459	# 3 4.040738	# 3 4.037306
# 4 3.967472	# 4 4.029147	# 4 4.045478	# 4 4.043970
# 5 3.975080	# 5 4.027123	# 5 4.045833	# 5 4.027271
# 6 4.030990	# 6 4.038440	# 6 4.025765	# 6 4.037481
# 7 3.968659	# 7 4.018794	# 7 4.039065	# 7 4.035394
# 8 4.034806	# 8 4.048854	# 8 4.047210	# 8 4.036290
# 9 4.033310	# 9 4.036625	# 9 4.024990	# 9 4.041507
#10 4.035870	#10 3.979129	#10 4.042094	#10 4.033540
#11 4.047125	#11 4.054167	#11 4.033348	#11 4.045985
#12 4.042790	#12 4.042710	#12 4.043454	#12 4.043445
#13 4.032910	#13 4.025466	#13 4.045829	#13 4.028232
#14 4.022786	#14 4.044390	#14 4.028927	#14 4.030938
#15 4.009917	#15 4.048726	#15 4.030465	#15 4.021639
#16 4.003486	#16 4.032674	#16 4.037030	#16 4.027148

TEST PERIOD # 6
FIRST PULL FOR 136CMS AND (DIFF.MATL) 65CMS. 450-255 CONDITIONS.
MAX TEMP 440C -- MIN TEMP 255C
START DATES AND ANY FRESH COUPONS ARE:

31079.12	31079.12	31079.12	31079.12
# 1 4.065535	# 1 4.002354	# 1 0.	# 1 0.
# 2 4.055485	# 2 4.001656	# 2 0.	# 2 0.
# 3 4.053114	# 3 3.994200	# 3 0.	# 3 0.
# 4 4.044325	# 4 3.997982	# 4 0.	# 4 0.
# 5 4.031182	# 5 3.991851	# 5 0.	# 5 0.
# 6 4.049306	# 6 3.990131	# 6 0.	# 6 0.
# 7 4.040734	# 7 3.988985	# 7 0.	# 7 0.
# 8 4.062266	# 8 3.999375	# 8 0.	# 8 0.
# 9 4.030631	# 9 3.995451	# 9 0.	# 9 0.
#10 4.047073	#10 3.987806	#10 0.	#10 0.
#11 4.042568	#11 3.991881	#11 0.	#11 0.
#12 4.058963	#12 4.031454	#12 4.035072	#12 4.039425
#13 4.055710	#13 4.003937	#13 0.	#13 0.
#14 4.052190	#14 4.003673	#14 0.	#14 0.
#15 4.054590	#15 4.003550	#15 0.	#15 0.
#16 4.060545	#16 4.000982	#16 0.	#16 0.

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

32179.08	32179.08	32179.08	32179.08
# 1 4.058854	# 1 3.995873	# 1 4.034347	# 1 4.026695
# 2 4.048655	# 2 3.995204	# 2 4.026779	# 2 4.020230
# 3 4.046511	# 3 3.988010	# 3 4.040187	# 3 4.036430
# 4 4.038540	# 4 3.991904	# 4 4.044925	# 4 4.043092
# 5 4.025376	# 5 3.985850	# 5 4.045365	# 5 4.026449
# 6 4.043900	# 6 3.984536	# 6 4.025300	# 6 4.036631
# 7 4.034685	# 7 3.983345	# 7 4.038585	# 7 4.034480
# 8 4.055973	# 8 3.993554	# 8 4.046664	# 8 4.035384
# 9 4.024978	# 9 3.989300	# 9 4.024415	# 9 4.040532
#10 4.041465	#10 3.981739	#10 4.041595	#10 4.032713
#11 4.037386	#11 3.985375	#11 4.032837	#11 4.045120
#12 4.053567	#12 4.027200	#12 4.031585	#12 4.034246
#13 4.049684	#13 3.997375	#13 4.044331	#13 4.027201
#14 4.046043	#14 3.997356	#14 4.028359	#14 4.029806
#15 4.048189	#15 3.997246	#15 4.029890	#15 4.020570
#16 4.054470	#16 3.994978	#16 4.030238	#16 4.026097

TEST PERIOD # 7
CONTINUING AT 450-255 CONDITIONS.
MAX TEMP 440C -- MIN TEMP 255C
START DATES AND ANY FRESH COUPONS ARE:

32379.08	32379.08	32379.08	32379.08
#16 4.043195	#16 4.049626	#11 4.057054	#11 4.032274

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

41179.12	41179.12	41179.12	41179.12
# 1 4.055990	# 1 3.993142	# 1 4.033464	# 1 4.025876
# 2 4.046189	# 2 3.992817	# 2 4.025921	# 2 4.019087
# 3 4.044247	# 3 3.985395	# 3 4.039529	# 3 4.035596
# 4 4.036104	# 4 3.989090	# 4 4.044217	# 4 4.042257
# 5 4.023157	# 5 3.982982	# 5 4.044648	# 5 4.025707
# 6 4.041660	# 6 3.981397	# 6 4.024555	# 6 4.035905
# 7 4.032447	# 7 3.980369	# 7 4.037876	# 7 4.033766
# 8 4.053719	# 8 3.990661	# 8 4.045961	# 8 4.034713
# 9 4.022818	# 9 3.986755	# 9 4.023740	# 9 4.039904
#10 4.039033	#10 3.979135	#10 4.040905	#10 4.031975
#11 4.035034	#11 3.983109	#11 4.052156	#11 4.025419
#12 4.051256	#12 4.025414	#12 4.029264	#12 4.032357
#13 4.047264	#13 3.994894	#13 4.043392	#13 4.026126
#14 4.043526	#14 3.994774	#14 4.027474	#14 4.028872
#15 4.045394	#15 3.994575	#15 4.029045	#15 4.019694
#16 4.036072	#16 4.043704	#16 4.029486	#16 4.025494

TEST PERIOD # 8
LAST PULL FOR 450-255 CONDITIONS.
MAX TEMP 440C -- MIN TEMP 255C
START DATES AND ANY FRESH COUPONS ARE:

41279.18	41279.18	41279.18	41279.18
#15 4.046392	#15 4.048050	#10 4.049206	#10 4.057269

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

50179.09	50179.09	50179.09	50179.09
# 1 4.050691	# 1 3.988315	# 1 4.030796	# 1 4.022566
# 2 4.040665	# 2 3.988608	# 2 4.023346	# 2 4.014849
# 3 4.038761	# 3 3.981390	# 3 4.037511	# 3 4.033045
# 4 4.030942	# 4 3.985056	# 4 4.042406	# 4 4.039555
# 5 4.018692	# 5 3.978935	# 5 4.042795	# 5 4.023040
# 6 4.037405	# 6 3.976858	# 6 4.022585	# 6 4.033470
# 7 4.026973	# 7 3.975950	# 7 4.035989	# 7 4.031300
# 8 4.048458	# 8 3.986416	# 8 4.044124	# 8 4.032270
# 9 4.017244	# 9 3.982424	# 9 4.021900	# 9 4.037652
#10 4.033800	#10 3.974894	#10 4.040685	#10 4.048036
#11 4.030522	#11 3.979120	#11 4.047860	#11 4.020625
#12 4.045996	#12 4.022241	#12 4.025786	#12 4.027910
#13 4.040200	#13 3.989385	#13 4.041160	#13 4.022690
#14 4.035648	#14 3.989664	#14 4.025182	#14 4.025590
#15 4.032415	#15 4.038981	#15 4.027130	#15 4.016006
#16 4.027969	#16 4.039489	#16 4.027424	#16 4.022649

TEST PERIOD # 9
FIRST PULL 450-340 CONDITIONS. SAME COUPONS.
MAX TEMP 440C -- MIN TEMP 340C
START DATES AND ANY FRESH COUPONS ARE:

50379.08	50379.08	50379.08	50379.08
#14 4.030746	#14 4.043487	# 9 4.042416	# 9 4.046985

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

52979.10	52979.10	52979.10	52979.10
# 1 4.048635	# 1 3.987255	# 1 4.029351	# 1 4.020322
# 2 4.038818	# 2 3.987834	# 2 4.021994	# 2 4.012714
# 3 4.037925	# 3 3.980565	# 3 4.036325	# 3 4.031232
# 4 4.029128	# 4 3.984179	# 4 4.041358	# 4 4.037561
# 5 4.016966	# 5 3.978052	# 5 4.041510	# 5 4.021387
# 6 4.035715	# 6 3.975920	# 6 4.021279	# 6 4.031708
# 7 4.025215	# 7 3.975014	# 7 4.034741	# 7 4.029601
# 8 4.046782	# 8 3.985631	# 8 4.042935	# 8 4.030356
# 9 4.015440	# 9 3.981694	# 9 4.033230	# 9 4.036539
#10 4.031990	#10 3.974205	#10 4.038835	#10 4.045530
#11 4.028816	#11 3.978504	#11 4.046368	#11 4.018522
#12 4.044285	#12 4.021508	#12 4.024495	#12 4.026045
#13 4.038300	#13 3.988857	#13 4.039631	#13 4.020490
#14 4.018404	#14 4.033365	#14 4.023890	#14 4.023630
#15 4.030249	#15 4.038476	#15 4.026040	#15 4.014040
#16 4.025954	#16 4.039390	#16 4.026439	#16 4.021070

TEST PERIOD #10
SECOND PULL 450-340 CONDITIONS.
MAX TEMP 440C -- MIN TEMP 340C
START DATES AND ANY FRESH COUPONS ARE:

53079.18	53079.18	53079.18	53079.18
#13 4.043362	#13 4.057284	# 8 4.041081	# 8 4.047830

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

72479.10	72479.10	72479.10	72479.10
# 1 4.045455	# 1 3.984834	# 1 4.026922	# 1 4.017716
# 2 4.036063	# 2 3.985784	# 2 4.019814	# 2 4.010039
# 3 4.034475	# 3 3.978512	# 3 4.034373	# 3 4.029044
# 4 4.026669	# 4 3.982039	# 4 4.039573	# 4 4.035260
# 5 4.014510	# 5 3.975755	# 5 4.039550	# 5 4.019179
# 6 4.033362	# 6 3.973615	# 6 4.019204	# 6 4.029567
# 7 4.022656	# 7 3.972584	# 7 4.032807	# 7 4.027593
# 8 4.044244	# 8 3.983192	# 8 4.032656	# 8 4.038000
# 9 4.013026	# 9 3.979351	# 9 4.027045	# 9 4.029754
#10 4.029723	#10 3.971920	#10 4.035887	#10 4.041926
#11 4.026617	#11 3.976081	#11 4.043904	#11 4.015843
#12 4.041936	#12 4.018664	#12 4.022103	#12 4.023429
#13 4.032574	#13 4.048092	#13 4.037100	#13 4.017817
#14 4.009956	#14 4.025090	#14 4.021860	#14 4.021228
#15 4.027128	#15 4.034576	#15 4.024086	#15 4.011745
#16 4.023548	#16 4.036472	#16 4.024654	#16 4.018733

TEST PERIOD #11
LAST PULL 450-340 CONDITIONS. LAST PULL THESE COUPONS.
MAX TEMP 440C -- MIN TEMP 340C
START DATES AND ANY FRESH COUPONS ARE:

73179.18	73179.18	73179.18	73179.18
#12 4.045148	#12 4.057429	# 7 4.049903	# 7 4.050256

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

92779.12	92779.12	92779.12	92779.12
# 1 4.044651	# 1 3.984822	# 1 4.026132	# 1 4.017113
# 2 4.035780	# 2 3.985882	# 2 4.019104	# 2 4.009705
# 3 4.033638	# 3 3.978569	# 3 4.033805	# 3 4.028595
# 4 4.025804	# 4 3.982040	# 4 4.039014	# 4 4.034811
# 5 4.013614	# 5 3.975765	# 5 4.038865	# 5 4.018795
# 6 4.032460	# 6 3.973556	# 6 4.018492	# 6 4.029149
# 7 4.021729	# 7 3.972520	# 7 4.044617	# 7 4.044409
# 8 4.043273	# 8 3.983148	# 8 4.029351	# 8 4.034756
# 9 4.011982	# 9 3.979310	# 9 4.024489	# 9 4.027526
#10 4.028600	#10 3.971914	#10 4.035005	#10 4.041532
#11 4.025598	#11 3.976325	#11 4.043326	#11 4.015683
#12 4.038668	#12 4.052581	#12 4.021400	#12 4.023315
#13 4.028240	#13 4.045160	#13 4.036225	#13 4.017432
#14 4.006547	#14 4.023500	#14 4.021146	#14 4.021040
#15 4.025940	#15 4.034591	#15 4.023480	#15 4.011621
#16 4.022162	#16 4.036519	#16 4.024149	#16 4.018548

TEST PERIOD #12
FIRST PULL 500-325 CONDITIONS, FRESH COUPONS. TOTAL 18 HRS.
MAX TEMP 490C -- MIN TEMP 325C
START DATES AND ANY FRESH COUPONS ARE:

100179.20	100179.20	100179.20	100179.20
# 1 3.954736	# 1 3.928997	# 1 3.940065	# 1 3.978600
# 2 3.984680	# 2 3.991745	# 2 3.982648	# 2 3.983229
# 3 3.983305	# 3 3.982787	# 3 3.991518	# 3 3.996423
# 4 3.982110	# 4 4.007411	# 4 4.004592	# 4 3.983851
# 5 3.982600	# 5 4.003080	# 5 4.000418	# 5 3.981344
# 6 3.973775	# 6 4.004150	# 6 3.989539	# 6 4.004552
# 7 4.006980	# 7 3.985295	# 7 3.982367	# 7 3.970566
# 8 3.981500	# 8 4.010037	# 8 3.971270	# 8 3.975786
# 9 3.983946	# 9 4.011541	# 9 4.006733	# 9 4.011551
#10 3.986841	#10 3.985814	#10 3.979164	#10 3.998932
#11 3.980847	#11 3.986662	#11 4.002360	#11 3.985386
#12 3.978976	#12 3.986118	#12 3.978071	#12 3.993072
#13 4.009766	#13 3.995282	#13 3.984761	#13 4.003184
#14 3.992393	#14 4.005603	#14 3.967687	#14 3.968137
#15 4.006667	#15 3.969859	#15 3.986958	#15 3.990154
#16 3.979718	#16 3.988722	#16 4.006575	#16 3.888146

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

100279.14	100279.14	100279.14	100279.14
# 1 3.952727	# 1 3.927189	# 1 3.937900	# 1 3.976262
# 2 3.982482	# 2 3.990096	# 2 3.980780	# 2 3.981105
# 3 3.981065	# 3 3.981292	# 3 3.989792	# 3 3.994425
# 4 3.979864	# 4 4.005900	# 4 4.003096	# 4 3.981675
# 5 3.980401	# 5 4.001292	# 5 3.998908	# 5 3.979331
# 6 3.971651	# 6 4.002560	# 6 3.987005	# 6 4.002746
# 7 4.004889	# 7 3.983875	# 7 3.980845	# 7 3.968505
# 8 3.979325	# 8 4.008771	# 8 3.969755	# 8 3.974016
# 9 3.981772	# 9 4.010281	# 9 4.005490	# 9 4.009785
#10 3.984752	#10 3.984479	#10 3.979007	#10 3.996758
#11 3.978946	#11 3.984963	#11 4.001079	#11 3.983366
#12 3.977216	#12 3.984550	#12 3.976738	#12 3.991277
#13 4.007762	#13 3.993534	#13 3.983094	#13 4.001150
#14 3.990425	#14 4.003800	#14 3.965944	#14 3.965964
#15 4.004536	#15 3.968006	#15 3.985250	#15 3.987783
#16 3.977596	#16 3.987142	#16 4.005029	#16 3.885918

TEST PERIOD #13
CONTINUING 500-325 CONDITIONS. TOTAL 36 HRS.
MAX TEMP 490C -- MIN TEMP 325C
START DATES AND ANY FRESH COUPONS ARE:

100379.19	100379.19	100379.19	100379.19

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

100479.13	100479.13	100479.13	100479.13
# 1 3.951464	# 1 3.925666	# 1 3.936378	# 1 3.974915
# 2 3.981256	# 2 3.988429	# 2 3.979380	# 2 3.979719
# 3 3.979736	# 3 3.979729	# 3 3.988201	# 3 3.993108
# 4 3.978591	# 4 4.004392	# 4 4.001695	# 4 3.980342
# 5 3.978971	# 5 3.999711	# 5 3.997639	# 5 3.977951
# 6 3.970382	# 6 4.001100	# 6 3.985664	# 6 4.001346
# 7 4.003620	# 7 3.982364	# 7 3.979495	# 7 3.967222
# 8 3.977940	# 8 4.007290	# 8 3.968427	# 8 3.972706
# 9 3.980404	# 9 4.008545	# 9 4.004162	# 9 4.008486
#10 3.983088	#10 3.982447	#10 3.976847	#10 3.995390
#11 3.977258	#11 3.983402	#11 3.999817	#11 3.981971
#12 3.975304	#12 3.983004	#12 3.975510	#12 3.989929
#13 4.006057	#13 3.991773	#13 3.981838	#13 3.999632
#14 3.988649	#14 4.002239	#14 3.964638	#14 3.964448
#15 4.002905	#15 3.966377	#15 3.984026	#15 3.986272
#16 3.975945	#16 3.985529	#16 4.003817	#16 3.884476

TEST PERIOD #14
CONTINUING 500-325 CONDITIONS. TOTAL 74 HRS.
MAX TEMP 490C -- MIN TEMP 325C
START DATES AND ANY FRESH COUPONS ARE:

101079.20	101079.20	101079.20	101079.20

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

101279.10	101279.10	101279.10	101279.10
# 1 3.949174	# 1 3.923765	# 1 3.934313	# 1 3.972671
# 2 3.978994	# 2 3.986467	# 2 3.977435	# 2 3.977416
# 3 3.977346	# 3 3.977649	# 3 3.986204	# 3 3.990890
# 4 3.976174	# 4 4.002304	# 4 3.999505	# 4 3.977996
# 5 3.976383	# 5 3.997743	# 5 3.995465	# 5 3.975647
# 6 3.968093	# 6 3.999010	# 6 3.983644	# 6 3.999109
# 7 4.001171	# 7 3.980231	# 7 3.977493	# 7 3.965070
# 8 3.975616	# 8 4.005239	# 8 3.966200	# 8 3.970475
# 9 3.978377	# 9 4.006555	# 9 4.002094	# 9 4.006350
#10 3.980985	#10 3.980733	#10 3.974882	#10 3.993311
#11 3.975116	#11 3.981330	#11 3.997596	#11 3.979704
#12 3.973115	#12 3.980851	#12 3.973262	#12 3.987804
#13 4.004217	#13 3.989875	#13 3.979589	#13 3.997303
#14 3.986535	#14 4.000418	#14 3.962366	#14 3.962545
#15 4.000991	#15 3.964516	#15 3.981781	#15 3.984463
#16 3.973974	#16 3.983669	#16 4.001845	#16 3.882661

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TEST PERIOD #15
CONTINUING 500-325 CONDITIONS. COUPONS IN FOR 4.5 DAYS THIS TIME.
MAX TEMP 490C -- MIN TEMP 325C
START DATES AND ANY FRESH COUPONS ARE:

101979.20	101979.20	101979.20	101979.20

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

102479.09	102479.09	102479.09	102479.09
# 1 3.947016	# 1 3.922019	# 1 3.932614	# 1 3.970716
# 2 3.976795	# 2 3.984549	# 2 3.975891	# 2 3.975389
# 3 3.975235	# 3 3.975640	# 3 3.984667	# 3 3.988865
# 4 3.974054	# 4 4.000268	# 4 3.997734	# 4 3.976045
# 5 3.974262	# 5 3.995689	# 5 3.993547	# 5 3.973754
# 6 3.966098	# 6 3.996987	# 6 3.981792	# 6 3.997230
# 7 3.998981	# 7 3.978117	# 7 3.975650	# 7 3.962919
# 8 3.973555	# 8 4.003134	# 8 3.964292	# 8 3.968408
# 9 3.976284	# 9 4.004666	# 9 3.999984	# 9 4.004316
#10 3.979076	#10 3.973809	#10 3.972905	#10 3.991453
#11 3.973059	#11 3.979702	#11 3.995586	#11 3.977589
#12 3.971013	#12 3.978935	#12 3.971184	#12 3.985703
#13 4.002289	#13 3.988274	#13 3.977594	#13 3.995277
#14 3.984605	#14 3.998779	#14 3.960619	#14 3.960790
#15 3.999080	#15 3.963030	#15 3.980054	#15 3.982705
#16 3.971876	#16 3.982125	#16 4.000090	#16 3.860874

TEST PERIOD #16
TWO MORE DAYS AT 500-325, CHECKING EFFECT OF INTERVAL
MAX TEMP 490C -- MIN TEMP 325C
START DATES AND ANY FRESH COUPONS ARE:

102779.15	102779.15	102779.15	102779.15

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

102979.08	102979.08	102979.08	102979.08
# 1 3.945468	# 1 3.920931	# 1 3.931177	# 1 3.968728
# 2 3.975511	# 2 3.983569	# 2 3.974867	# 2 3.973546
# 3 3.973874	# 3 3.974671	# 3 3.983647	# 3 3.987223
# 4 3.972800	# 4 3.999234	# 4 3.996706	# 4 3.974210
# 5 3.972951	# 5 3.994785	# 5 3.992506	# 5 3.972321
# 6 3.964786	# 6 3.996020	# 6 3.980581	# 6 3.996011
# 7 3.997640	# 7 3.977126	# 7 3.974412	# 7 3.961487
# 8 3.972000	# 8 4.002197	# 8 3.962665	# 8 3.966961
# 9 3.975069	# 9 4.003614	# 9 3.998551	# 9 4.003160
#10 3.977946	#10 3.977778	#10 3.971057	#10 3.990160
#11 3.971965	#11 3.978757	#11 3.993611	#11 3.976194
#12 3.969759	#12 3.977934	#12 3.969319	#12 3.984415
#13 4.000959	#13 3.987312	#13 3.975735	#13 3.993904
#14 3.983411	#14 3.997893	#14 3.959253	#14 3.959314
#15 3.997667	#15 3.962218	#15 3.978956	#15 3.981392
#16 3.970295	#16 3.981196	#16 3.999246	#16 3.879708

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TEST PERIOD #17
TWO WEEKS MORE AT 500-325....
MAX TEMP   490C -- MIN TEMP   325C
START DATES AND ANY FRESH COUPONS ARE:
   103079.20        103079.20        103079.20        103079.20

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:
   111679.09        111679.09        111679.09        111679.09
# 1 3.942619     # 1 3.919682     # 1 3.928246     # 1 3.965246
# 2 3.972728     # 2 3.982520     # 2 3.972348     # 2 3.970135
# 3 3.970985     # 3 3.973752     # 3 3.981207     # 3 3.984041
# 4 3.969825     # 4 3.998278     # 4 3.994212     # 4 3.970880
# 5 3.969888     # 5 3.993863     # 5 3.989665     # 5 3.969243
# 6 3.961620     # 6 3.995071     # 6 3.977502     # 6 3.992977
# 7 3.994090     # 7 3.975839     # 7 3.970941     # 7 3.958166
# 8 3.968452     # 8 4.000748     # 8 3.950679     # 8 3.963830
# 9 3.971539     # 9 4.001943     # 9 3.994284     # 9 4.000249
#10 3.974303     #10 3.975607     #10 3.966180     #10 3.987025
#11 3.968174     #11 3.975866     #11 3.988558     #11 3.972967
#12 3.965765     #12 3.974552     #12 3.965056     #12 3.981124
#13 3.996697     #13 3.983824     #13 3.971296     #13 3.990707
#14 3.978945     #14 3.994090     #14 3.955846     #14 3.956248
#15 3.993196     #15 3.958504     #15 3.975906     #15 3.978281
#16 3.966091     #16 3.977838     #16 3.996029     #16 3.877094


TEST PERIOD #18
ALMOST FOUR WEEKS MORE AT 500-325 NOMINAL TEMPERATURES
MAX TEMP   490C -- MIN TEMP   325C
START DATES AND ANY FRESH COUPONS ARE:
   121079.18        121079.18        121079.18        121079.18

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:
    10780.09         10780.09         10780.09         10780.09
# 1 3.924214     # 1 3.905233     # 1 3.913212     # 1 3.948278
# 2 3.955391     # 2 3.968572     # 2 3.958606     # 2 3.953246
# 3 3.954329     # 3 3.960714     # 3 3.969110     # 3 3.970248
# 4 3.953181     # 4 3.984020     # 4 3.982323     # 4 3.955566
# 5 3.954191     # 5 3.978975     # 5 3.978165     # 5 3.955094
# 6 3.944895     # 6 3.980973     # 6 3.965756     # 6 3.980143
# 7 3.975739     # 7 3.961242     # 7 3.959324     # 7 3.945119
# 8 3.950173     # 8 3.988220     # 8 3.947170     # 8 3.951199
# 9 3.952741     # 9 3.989925     # 9 3.983372     # 9 3.988050
#10 3.956396     #10 3.964159     #10 3.955548     #10 3.974265
#11 3.952043     #11 3.964602     #11 3.977937     #11 3.959588
#12 3.946973     #12 3.962300     #12 3.954903     #12 3.967751
#13 3.977767     #13 3.970155     #13 3.960085     #13 3.976174
#14 3.959358     #14 3.981185     #14 3.944700     #14 3.939388
#15 3.974357     #15 3.945489     #15 3.966241     #15 3.960837
#16 3.947050     #16 3.964605     #16 3.985885     #16 3.861205
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TEST PERIOD #19
SEVEN MORE WEEKS 500-325
MAX TEMP 490C -- MIN TEMP 325C
START DATES AND ANY FRESH COUPONS ARE:

10880.19	10880.19	10880.19	10880.19
#16 4.013940	#16 3.979610	#16 3.992908	#16 3.989071

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

22680.09	22680.09	22680.09	22680.09
# 1 3.921615	# 1 3.903643	# 1 3.911715	# 1 3.945752
# 2 3.952891	# 2 3.966846	# 2 3.957241	# 2 3.950884
# 3 3.951764	# 3 3.958721	# 3 3.967717	# 3 3.967785
# 4 3.950645	# 4 3.981925	# 4 3.980702	# 4 3.952945
# 5 3.951540	# 5 3.976985	# 5 3.976475	# 5 3.952494
# 6 3.942190	# 6 3.978877	# 6 3.963904	# 6 3.977534
# 7 3.973025	# 7 3.958982	# 7 3.957451	# 7 3.942605
# 8 3.947514	# 8 3.985995	# 8 3.945304	# 8 3.948745
# 9 3.950172	# 9 3.987754	# 9 3.981320	# 9 3.985516
#10 3.953754	#10 3.961943	#10 3.953413	#10 3.971925
#11 3.949493	#11 3.962460	#11 3.975728	#11 3.957250
#12 3.944356	#12 3.960112	#12 3.952904	#12 3.965375
#13 3.975059	#13 3.967958	#13 3.958104	#13 3.973864
#14 3.956700	#14 3.979028	#14 3.943093	#14 3.937110
#15 3.971700	#15 3.943245	#15 3.964611	#15 3.958586
#16 4.009724	#16 3.974690	#16 3.987619	#16 3.984320

TEST PERIOD #20
THREE MORE WEEKS AT 500-325 NOMINAL(PULL 3/19;LEAP YEAR SO SAY 3/20
MAX TEMP 490C -- MIN TEMP 325C
START DATES AND ANY FRESH COUPONS ARE:

22880.17	22880.17	22880.17	22880.17

TEST PERIOD END DATES AND COUPON WEIGHTS IN GRAMS:

32080.09	32080.09	32080.09	32080.09
# 1 3.919472	# 1 3.902732	# 1 3.910971	# 1 3.943874
# 2 3.950893	# 2 3.965978	# 2 3.956580	# 2 3.949204
# 3 3.949680	# 3 3.957625	# 3 3.967048	# 3 3.966198
# 4 3.948633	# 4 3.980795	# 4 3.979930	# 4 3.951275
# 5 3.949525	# 5 3.976084	# 5 3.975720	# 5 3.950894
# 6 3.940271	# 6 3.977951	# 6 3.963088	# 6 3.975900
# 7 3.971163	# 7 3.957935	# 7 3.956611	# 7 3.941077
# 8 3.945715	# 8 3.985036	# 8 3.944479	# 8 3.947285
# 9 3.948365	# 9 3.986719	# 9 3.980479	# 9 3.984100
#10 3.952047	#10 3.960912	#10 3.952573	#10 3.970589
#11 3.947930	#11 3.961455	#11 3.974869	#11 3.955931
#12 3.942741	#12 3.959077	#12 3.952093	#12 3.963968
#13 3.973389	#13 3.966973	#13 3.957325	#13 3.972561
#14 3.954974	#14 3.978145	#14 3.942410	#14 3.935851
#15 3.970002	#15 3.942376	#15 3.963981	#15 3.957411
#16 4.007781	#16 3.972874	#16 3.986052	#16 3.982118

PULL NUMBER 1, ON 101278.
440- 255C,

MG LOSS IN 22 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	6.6	5.4	5.2	5.2	6.6 @-22	5.4 @-19	5.2 @-22	5.2 @-19
2	6.3	4.9	7.2	5.0	6.3 @-22	4.9 @-19	7.2 @-22	5.0 @-19
3	5.7	4.4	4.6	4.5	5.7 @-22	4.4 @-19	4.6 @-22	4.5 @-19
4	8.3	4.6	4.7	4.2	8.3 @-22	4.6 @-19	4.7 @-22	4.2 @-19
5	7.6	4.5	4.8	3.9	7.6 @-22	4.5 @-19	4.8 @-22	3.9 @-19
6	5.3	4.1	4.6	3.9	5.3 @-22	4.1 @-19	4.6 @-22	3.9 @-19
7	8.2	4.2	4.6	4.6	8.2 @-22	4.2 @-19	4.6 @-22	4.6 @-19
8	5.6	4.3	4.7	3.9	5.6 @-22	4.3 @-19	4.7 @-22	3.9 @-19
9	5.4	4.2	4.7	4.2	5.4 @-22	4.2 @-19	4.7 @-22	4.2 @-19
10	4.8	4.5	6.4	3.9	4.8 @-22	4.5 @-19	6.4 @-22	3.9 @-19
11	5.2	4.3	3.9	3.6	5.2 @-22	4.3 @-19	3.9 @-22	3.6 @-19
12	5.6	4.2	3.7	3.5	5.6 @-22	4.2 @-19	3.7 @-22	3.5 @-19
13	6.0	4.3	3.9	3.7	6.0 @-22	4.3 @-19	3.9 @-22	3.7 @-19
14	9.4	4.5	4.7	3.8	9.4 @-22	4.5 @-19	4.7 @-22	3.8 @-19
15	6.0	4.7	5.0	3.6	6.0 @-22	4.7 @-19	5.0 @-22	3.6 @-19
16	5.9	4.9	4.5	3.6	5.9 @-22	4.9 @-19	4.5 @-22	3.6 @-19

PULL NUMBER 2, ON 110878.
440- 255C,

MG LOSS IN 19 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.2	3.0	1.1	1.7	8.8 @ 41	8.4 @ 38	6.2 @ 41	6.9 @ 38
2	2.0	3.2	1.5	1.5	8.3 @ 41	8.1 @ 38	8.8 @ 41	6.5 @ 38
3	1.9	2.4	1.0	1.3	7.5 @ 41	6.8 @ 38	5.6 @ 41	5.8 @ 38
4	2.3	2.4	1.2	1.3	10.6 @ 41	7.1 @ 38	5.9 @ 41	5.5 @ 38
5	2.1	2.2	1.1	1.3	9.6 @ 41	6.7 @ 38	5.8 @ 41	5.3 @ 38
6	1.4	2.1	1.1	1.4	6.7 @ 41	6.2 @ 38	5.6 @ 41	5.2 @ 38
7	2.4	2.1	1.1	1.2	10.6 @ 41	6.2 @ 38	5.7 @ 41	5.8 @ 38
8	1.5	2.1	0.9	1.1	7.2 @ 41	6.4 @ 38	5.5 @ 41	5.0 @ 38
9	1.5	2.0	0.9	1.2	6.9 @ 41	6.3 @ 38	5.6 @ 41	5.4 @ 38
10	1.5	2.2	1.4	1.2	6.3 @ 41	6.7 @ 38	7.8 @ 41	5.0 @ 38
11	1.4	2.2	0.9	1.2	6.6 @ 41	6.6 @ 38	4.9 @ 41	4.8 @ 38
12	1.5	2.2	0.9	1.1	7.0 @ 41	6.4 @ 38	4.7 @ 41	4.6 @ 38
13	1.7	2.2	0.8	1.1	7.8 @ 41	6.5 @ 38	4.7 @ 41	4.8 @ 38
14	2.6	2.3	1.0	1.1	12.0 @ 41	6.9 @ 38	5.7 @ 41	4.9 @ 38
15	1.7	2.5	1.1	1.1	7.7 @ 41	7.2 @ 38	6.1 @ 41	4.8 @ 38
16	7.8	5.3	5.3	3.6	7.8 @-19	5.3 @-19	5.3 @-19	3.6 @-19

PULL NUMBER 3. ON 121178.
440- 255C,

MG LOSS IN 22 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	3.3	2.5	1.8	1.9	12.0 @ 63	10.9 @ 60	8.0 @ 63	8.7 @ 60
2	2.9	3.1	2.0	1.7	11.2 @ 63	11.2 @ 60	10.7 @ 63	8.1 @ 60
3	2.6	2.2	1.5	1.4	10.1 @ 63	9.0 @ 60	7.2 @ 63	7.2 @ 60
4	3.2	2.3	1.6	1.4	13.8 @ 63	9.4 @ 60	7.5 @ 63	6.9 @ 60
5	3.0	2.1	1.6	1.5	12.6 @ 63	8.8 @ 60	7.4 @ 63	6.8 @ 60
6	2.6	1.9	1.6	1.6	9.3 @ 63	8.1 @ 60	7.2 @ 63	6.8 @ 60
7	3.5	2.0	1.2	1.4	14.0 @ 63	8.2 @ 60	6.9 @ 63	7.2 @ 60
8	2.8	2.0	1.3	1.3	10.0 @ 63	8.4 @ 60	6.8 @ 63	6.4 @ 60
9	3.1	2.0	1.3	1.4	10.0 @ 63	8.3 @ 60	6.9 @ 63	6.8 @ 60
10	3.3	2.2	1.5	1.3	9.6 @ 63	8.9 @ 60	9.3 @ 63	6.3 @ 60
11	2.3	2.1	1.3	1.3	8.9 @ 63	8.6 @ 60	6.2 @ 63	6.1 @ 60
12	2.4	2.0	1.4	1.3	9.4 @ 63	8.4 @ 60	6.0 @ 63	5.9 @ 60
13	3.0	2.2	1.2	1.3	10.8 @ 63	8.6 @ 60	5.9 @ 63	6.2 @ 60
14	3.8	2.0	1.4	1.3	15.7 @ 63	8.8 @ 60	7.0 @ 63	6.2 @ 60
15	7.5	5.8	4.8	4.1	7.5 @-22	5.8 @-22	4.8 @-22	4.1 @-22
16	4.5	3.2	2.4	2.2	12.3 @ 41	8.5 @ 41	7.7 @ 41	5.8 @ 41

PULL NUMBER 4. ON 11679.
440- 255C,

MG LOSS IN 28 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	4.1	3.6	2.7	2.7	16.1 @ 92	14.6 @ 89	10.7 @ 92	11.4 @ 89
2	4.2	4.2	2.9	2.5	15.4 @ 92	15.4 @ 89	13.7 @ 92	10.6 @ 89
3	3.4	3.3	2.5	2.1	13.5 @ 92	12.3 @ 89	9.7 @ 92	9.4 @ 89
4	3.8	3.4	2.7	2.1	17.6 @ 92	12.8 @ 89	10.2 @ 92	9.0 @ 89
5	3.5	3.1	2.6	2.2	16.1 @ 92	11.9 @ 89	10.0 @ 92	9.0 @ 89
6	3.6	2.8	2.5	2.0	12.9 @ 92	10.9 @ 89	9.7 @ 92	8.8 @ 89
7	5.2	2.9	2.7	1.7	19.3 @ 92	11.2 @ 89	9.6 @ 92	8.9 @ 89
8	3.9	2.6	2.7	1.8	13.9 @ 92	11.0 @ 89	9.5 @ 92	8.2 @ 89
9	3.3	2.7	3.4	2.0	13.2 @ 92	10.9 @ 89	10.3 @ 92	8.9 @ 89
10	3.1	3.1	3.6	1.9	12.7 @ 92	12.0 @ 89	13.0 @ 92	8.2 @ 89
11	3.1	3.0	2.7	1.7	12.0 @ 92	11.6 @ 89	8.9 @ 92	7.8 @ 89
12	3.4	3.0	2.8	1.9	12.8 @ 92	11.3 @ 89	8.8 @ 92	7.7 @ 89
13	4.4	3.2	2.6	1.8	15.2 @ 92	11.8 @ 89	8.6 @ 92	8.0 @ 89
14	8.3	6.8	5.7	4.8	8.3 @-28	6.8 @-28	5.7 @-28	4.8 @-28
15	5.8	4.3	3.0	2.6	13.3 @ 51	10.1 @ 51	7.8 @ 51	6.7 @ 51
16	4.5	3.7	3.0	2.2	16.8 @ 70	12.1 @ 70	10.7 @ 70	8.0 @ 70

PULL NUMBER 5. ON 30879.
440- 255C,

MG LOSS IN 48 DAYS -- CUMULATIVE LOSS MM.M MG @ DDD DAYS

COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	7.0	5.3	4.6	5.2	23.1 @141	19.9 @138	15.3 @141	16.6 @138
2	6.8	6.0	4.7	4.5	22.1 @141	21.4 @138	18.3 @141	15.1 @138
3	5.6	4.8	4.7	4.0	19.2 @141	17.1 @138	14.4 @141	13.4 @138
4	5.7	5.2	4.4	3.9	23.3 @141	18.0 @138	14.6 @141	12.9 @138
5	5.4	4.7	4.5	3.7	21.5 @141	16.6 @138	14.5 @141	12.8 @138
6	5.8	5.0	4.4	3.9	18.7 @141	15.9 @138	14.1 @141	12.7 @138
7	7.5	4.7	4.4	3.8	26.8 @141	15.9 @138	13.9 @141	12.7 @138
8	7.1	4.5	3.9	3.5	21.0 @141	15.5 @138	13.4 @141	11.7 @138
9	5.8	4.3	3.5	3.7	19.0 @141	15.2 @138	13.8 @141	12.6 @138
10	5.1	4.5	3.9	3.5	17.8 @141	16.5 @138	16.9 @141	11.7 @138
11	5.5	5.0	4.0	3.3	17.5 @141	16.6 @138	12.9 @141	11.1 @138
12	6.5	5.3	4.2	3.5	19.4 @141	16.6 @138	13.0 @141	11.3 @138
13	12.3	9.5	7.9	6.2	12.3 @-48	9.5 @-48	7.9 @-48	6.2 @-48
14	8.8	6.7	5.5	4.6	17.1 @ 77	13.5 @ 77	11.2 @ 77	9.4 @ 77
15	8.8	6.7	5.4	4.0	22.1 @100	16.8 @100	13.2 @100	10.8 @100
16	7.0	6.0	3.9	-2.3	23.8 @119	18.1 @119	14.5 @119	5.7 @119

PULL NUMBER 6. ON 32179.
440- 255C,

MG LOSS IN 10 DAYS -- CUMULATIVE LOSS MM.M MG @ DDD DAYS

COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	6.7	1.0	6.5	0.8	6.7 @-10	20.9 @149	6.5 @-10	17.5 @149
2	6.8	1.1	6.5	0.7	6.8 @-10	22.5 @149	6.5 @-10	15.9 @149
3	6.6	0.9	6.2	0.6	6.6 @-10	18.0 @149	6.2 @-10	13.9 @149
4	5.8	0.9	6.1	0.6	5.8 @-10	18.9 @149	6.1 @-10	13.4 @149
5	5.8	0.8	6.0	0.5	5.8 @-10	17.4 @149	6.0 @-10	13.2 @149
6	5.4	0.9	5.6	0.5	5.4 @-10	16.8 @149	5.6 @-10	13.2 @149
7	6.0	0.9	5.6	0.5	6.0 @-10	16.8 @149	5.6 @-10	13.1 @149
8	6.3	0.9	5.8	0.5	6.3 @-10	16.4 @149	5.8 @-10	12.2 @149
9	5.7	1.0	6.2	0.6	5.7 @-10	16.2 @149	6.2 @-10	13.1 @149
10	5.6	0.8	6.1	0.5	5.6 @-10	17.4 @149	6.1 @-10	12.2 @149
11	5.2	0.9	6.5	0.5	5.2 @-10	17.5 @149	6.5 @-10	11.6 @149
12	5.4	5.2	4.3	3.5	5.4 @-10	5.2 @-10	4.3 @-10	3.5 @-10
13	6.0	1.0	6.6	1.5	6.0 @-10	10.5 @ 59	6.6 @-10	7.7 @ 59
14	6.1	1.1	6.3	0.6	6.1 @-10	14.6 @ 88	6.3 @-10	10.0 @ 88
15	6.4	1.1	6.3	0.6	6.4 @-10	17.8 @111	6.3 @-10	11.3 @111
16	6.1	1.1	6.0	6.8	6.1 @-10	19.2 @130	6.0 @-10	12.5 @130

PULL NUMBER 7, ON 41179.
440- 255C,

MG LOSS IN 18 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.9	0.8	2.7	0.9	9.5 @ 29	21.7 @167	9.2 @ 29	18.4 @167
2	2.5	1.1	2.4	0.9	9.3 @ 29	23.7 @167	8.8 @ 29	16.7 @167
3	2.3	0.8	2.6	0.7	8.9 @ 29	18.8 @167	8.8 @ 29	14.6 @167
4	2.4	0.8	2.8	0.7	8.2 @ 29	19.7 @167	8.9 @ 29	14.1 @167
5	2.2	0.7	2.9	0.7	8.0 @ 29	18.1 @167	8.9 @ 29	13.9 @167
6	2.2	0.7	3.1	0.7	7.6 @ 29	17.5 @167	8.7 @ 29	13.9 @167
7	2.2	0.7	3.0	0.7	8.3 @ 29	17.5 @167	8.6 @ 29	13.8 @167
8	2.3	0.7	2.9	0.7	8.5 @ 29	17.1 @167	8.7 @ 29	12.9 @167
9	2.2	0.6	2.5	0.7	7.0 @ 29	16.8 @167	8.7 @ 29	13.8 @167
10	2.4	0.7	2.6	0.7	8.0 @ 29	18.1 @167	8.7 @ 29	12.9 @167
11	2.4	6.9	2.3	4.9	7.5 @ 29	6.9 @-18	8.8 @ 29	4.9 @-18
12	2.3	1.9	1.8	2.3	7.7 @ 29	7.1 @ 29	6.0 @ 29	5.8 @ 29
13	2.4	1.1	2.5	0.9	8.4 @ 29	11.6 @ 77	9.0 @ 29	8.6 @ 77
14	2.5	0.9	2.6	0.9	8.7 @ 29	15.5 @106	8.9 @ 29	10.9 @106
15	2.8	0.9	2.7	0.8	9.2 @ 29	18.7 @129	9.0 @ 29	12.2 @129
16	7.1	0.6	5.9	0.8	7.1 @-18	19.8 @148	5.9 @-18	13.3 @148

PULL NUMBER 8, ON 50179.
440- 255C,

MG LOSS IN 18 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	5.3	3.3	4.8	2.7	14.8 @ 47	25.1 @186	14.0 @ 47	21.0 @186
2	5.5	4.2	4.2	2.6	14.8 @ 47	27.9 @186	13.0 @ 47	19.3 @186
3	5.5	2.6	4.0	2.0	14.4 @ 47	21.4 @186	12.8 @ 47	16.6 @186
4	5.2	2.7	4.0	1.8	13.4 @ 47	22.4 @186	12.9 @ 47	16.0 @186
5	4.5	2.7	4.0	1.9	12.5 @ 47	20.8 @186	12.9 @ 47	15.8 @186
6	4.3	2.4	4.5	2.0	11.9 @ 47	19.9 @186	13.3 @ 47	15.9 @186
7	5.5	2.5	4.4	1.9	13.8 @ 47	19.9 @186	13.0 @ 47	15.7 @186
8	5.3	2.4	4.2	1.8	13.8 @ 47	19.5 @186	13.0 @ 47	14.8 @186
9	5.6	2.3	4.3	1.8	13.4 @ 47	19.1 @186	13.0 @ 47	15.6 @186
10	5.2	9.2	4.2	8.5	13.3 @ 47	9.2 @-18	12.9 @ 47	8.5 @-18
11	4.5	4.8	4.0	4.3	12.0 @ 47	11.6 @ 36	12.8 @ 47	9.2 @ 36
12	5.3	4.4	3.2	3.5	13.0 @ 47	11.5 @ 47	9.2 @ 47	9.3 @ 47
13	7.1	3.4	5.5	2.2	15.5 @ 47	15.0 @ 96	14.6 @ 47	10.8 @ 96
14	7.9	3.3	5.1	2.3	16.5 @ 47	18.8 @125	14.0 @ 47	13.2 @125
15	14.0	3.7	9.1	1.9	14.0 @-18	22.4 @148	9.1 @-18	14.1 @148
16	8.1	2.8	4.2	2.1	15.2 @ 36	22.6 @167	10.1 @ 36	15.3 @167

PULL NUMBER 9, ON 52979.
440- 340C,

MG LOSS IN 26 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.1	2.2	1.1	1.4	16.9 @ 73	27.3 @212	15.1 @ 73	22.5 @212
2	1.8	2.1	0.8	1.4	16.7 @ 73	30.0 @212	13.8 @ 73	20.6 @212
3	0.8	1.8	0.8	1.2	15.2 @ 73	23.2 @212	13.6 @ 73	17.8 @212
4	1.8	2.0	0.9	1.0	15.2 @ 73	24.4 @212	13.8 @ 73	17.0 @212
5	1.7	1.7	0.9	1.3	14.2 @ 73	22.5 @212	13.8 @ 73	17.1 @212
6	1.7	1.8	0.9	1.3	13.6 @ 73	21.7 @212	14.2 @ 73	17.2 @212
7	1.8	1.7	0.9	1.2	15.5 @ 73	21.6 @212	14.0 @ 73	17.0 @212
8	1.7	1.9	0.8	1.2	15.5 @ 73	21.5 @212	13.7 @ 73	16.0 @212
9	1.8	10.4	0.7	9.2	15.2 @ 73	10.4 @-26	13.8 @ 73	9.2 @-26
10	1.8	2.5	0.7	1.8	15.1 @ 73	11.7 @ 44	13.6 @ 73	10.4 @ 44
11	1.7	2.1	0.6	1.5	13.8 @ 73	13.8 @ 62	13.4 @ 73	10.7 @ 62
12	1.7	1.9	0.7	1.3	14.7 @ 73	13.4 @ 73	9.9 @ 73	10.6 @ 73
13	1.9	2.2	0.5	1.5	17.4 @ 73	17.2 @122	15.1 @ 73	12.4 @122
14	12.3	2.0	10.1	1.3	12.3 @-26	20.8 @151	10.1 @-26	14.5 @151
15	2.2	2.0	0.5	1.1	16.1 @ 44	24.4 @174	9.6 @ 44	15.2 @174
16	2.0	1.6	0.1	1.0	17.2 @ 62	24.2 @193	10.2 @ 62	16.3 @193

PULL NUMBER 10, ON 72479.
440- 340C,

MG LOSS IN 54 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	3.2	2.6	2.4	2.4	20.1 @128	29.9 @266	17.5 @128	24.9 @266
2	2.8	2.7	2.0	2.2	19.4 @128	32.7 @266	15.9 @128	22.8 @266
3	3.5	2.2	2.1	2.0	18.6 @128	25.4 @266	15.7 @128	19.7 @266
4	2.5	2.3	2.1	1.8	17.7 @128	26.7 @266	15.9 @128	18.8 @266
5	2.5	2.2	2.3	2.0	16.7 @128	24.7 @266	16.1 @128	19.0 @266
6	2.4	2.1	2.3	2.1	15.9 @128	23.8 @266	16.5 @128	19.3 @266
7	2.6	2.0	2.4	1.9	18.1 @128	23.7 @266	16.4 @128	18.9 @266
8	2.5	9.8	2.4	8.4	18.0 @128	9.8 @-54	16.2 @128	8.4 @-54
9	2.4	6.8	2.3	6.2	17.6 @128	17.2 @ 80	16.1 @128	15.4 @ 80
10	2.3	3.6	2.3	2.9	17.4 @128	15.3 @ 99	15.9 @128	13.3 @ 99
11	2.2	2.7	2.4	2.5	16.0 @128	16.4 @117	15.8 @128	13.1 @117
12	2.3	2.6	2.8	2.4	17.0 @128	16.0 @128	12.8 @128	13.0 @128
13	10.8	2.7	9.2	2.5	10.8 @-54	19.9 @177	9.2 @-54	14.9 @177
14	8.4	2.4	8.3	2.0	20.8 @ 80	23.2 @206	18.4 @ 80	16.5 @206
15	3.1	2.3	3.9	2.0	19.3 @ 99	26.7 @228	13.5 @ 99	17.1 @228
16	2.4	2.3	2.9	1.8	19.6 @117	26.6 @247	13.2 @117	18.1 @247

PULL NUMBER 11, ON 92779.
440- 340C,

MG LOSS IN 57 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	0.8	0.6	0.0	0.8	20.9 @186	30.5 @324	17.5 @186	25.7 @324
2	0.3	0.3	-0.1	0.7	19.7 @186	33.0 @324	15.8 @186	23.5 @324
3	0.8	0.4	-0.1	0.6	19.5 @186	25.8 @324	15.6 @186	20.3 @324
4	0.9	0.4	-0.0	0.6	18.5 @186	27.2 @324	15.9 @186	19.3 @324
5	0.9	0.4	-0.0	0.7	17.6 @186	25.0 @324	16.1 @186	19.7 @324
6	0.9	0.4	0.1	0.7	16.8 @186	24.2 @324	16.6 @186	20.0 @324
7	0.9	5.8	0.1	5.3	19.0 @186	5.8 @-57	16.5 @186	5.3 @-57
8	1.0	3.2	0.0	3.3	19.0 @186	13.1 @112	16.2 @186	11.7 @112
9	1.0	2.2	0.0	2.6	18.6 @186	19.5 @138	16.1 @186	17.9 @138
10	1.1	0.4	0.0	0.9	18.5 @186	15.7 @157	15.9 @186	14.2 @157
11	1.0	0.2	-0.2	0.6	17.0 @186	16.6 @175	15.6 @186	13.7 @175
12	6.5	0.1	4.8	0.7	6.5 @-57	16.1 @186	4.8 @-57	13.7 @186
13	4.3	0.4	2.9	0.9	15.1 @112	20.3 @234	12.1 @112	15.8 @234
14	3.4	0.2	1.6	0.7	24.2 @138	23.4 @263	20.0 @138	17.2 @263
15	1.2	0.1	-0.0	0.6	20.5 @157	26.8 @286	13.5 @157	17.7 @286
16	1.4	0.2	-0.0	0.5	21.0 @175	26.7 @305	13.1 @175	18.6 @305

PULL NUMBER 12, ON 100279.
490- 325C,

MG LOSS IN 0 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.0	2.3	1.8	2.2	2.0 @ -0	2.3 @ -0	1.8 @ -0	2.2 @ -0
2	2.2	2.1	1.6	1.9	2.2 @ -0	2.1 @ -0	1.6 @ -0	1.9 @ -0
3	2.2	2.0	1.5	1.7	2.2 @ -0	2.0 @ -0	1.5 @ -0	1.7 @ -0
4	2.2	2.2	1.5	1.5	2.2 @ -0	2.2 @ -0	1.5 @ -0	1.5 @ -0
5	2.2	2.0	1.8	1.5	2.2 @ -0	2.0 @ -0	1.8 @ -0	1.5 @ -0
6	2.1	1.8	1.6	2.5	2.1 @ -0	1.8 @ -0	1.6 @ -0	2.5 @ -0
7	2.1	2.1	1.4	1.5	2.1 @ -0	2.1 @ -0	1.4 @ -0	1.5 @ -0
8	2.2	1.8	1.3	1.5	2.2 @ -0	1.8 @ -0	1.3 @ -0	1.5 @ -0
9	2.2	1.8	1.3	1.2	2.2 @ -0	1.8 @ -0	1.3 @ -0	1.2 @ -0
10	2.1	2.2	1.3	1.2	2.1 @ -0	2.2 @ -0	1.3 @ -0	1.2 @ -0
11	1.9	2.0	1.7	1.3	1.9 @ -0	2.0 @ -0	1.7 @ -0	1.3 @ -0
12	1.8	1.8	1.6	1.3	1.8 @ -0	1.8 @ -0	1.6 @ -0	1.3 @ -0
13	2.0	2.0	1.7	1.7	2.0 @ -0	2.0 @ -0	1.7 @ -0	1.7 @ -0
14	2.0	2.2	1.8	1.7	2.0 @ -0	2.2 @ -0	1.8 @ -0	1.7 @ -0
15	2.1	2.4	1.9	1.7	2.1 @ -0	2.4 @ -0	1.9 @ -0	1.7 @ -0
16	2.1	2.2	1.6	1.5	2.1 @ -0	2.2 @ -0	1.6 @ -0	1.5 @ -0

PULL NUMBER 13, ON 100479.
490- 325C,

MG LOSS IN 0 DAYS -- CUMULATIVE LOSS MM.M MG @ DDD DAYS

COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	1.3	1.3	1.5	1.5	3.3 @ 1	3.7 @ 1	3.3 @ 1	3.7 @ 1
2	1.2	1.4	1.7	1.4	3.4 @ 1	3.5 @ 1	3.3 @ 1	3.3 @ 1
3	1.3	1.3	1.6	1.6	3.6 @ 1	3.3 @ 1	3.1 @ 1	3.3 @ 1
4	1.3	1.3	1.5	1.4	3.5 @ 1	3.5 @ 1	3.0 @ 1	2.9 @ 1
5	1.4	1.4	1.6	1.3	3.6 @ 1	3.4 @ 1	3.4 @ 1	2.8 @ 1
6	1.3	1.4	1.5	1.3	3.4 @ 1	3.2 @ 1	3.1 @ 1	3.9 @ 1
7	1.3	1.3	1.5	1.4	3.4 @ 1	3.3 @ 1	2.9 @ 1	2.9 @ 1
8	1.4	1.3	1.5	1.3	3.6 @ 1	3.1 @ 1	2.7 @ 1	2.8 @ 1
9	1.4	1.3	1.7	1.3	3.5 @ 1	3.1 @ 1	3.0 @ 1	2.6 @ 1
10	1.7	1.4	2.0	1.2	3.8 @ 1	3.5 @ 1	3.4 @ 1	2.3 @ 1
11	1.7	1.4	1.6	1.3	3.6 @ 1	3.4 @ 1	3.3 @ 1	2.5 @ 1
12	1.9	1.3	1.5	1.2	3.7 @ 1	3.1 @ 1	3.1 @ 1	2.6 @ 1
13	1.7	1.5	1.8	1.3	3.7 @ 1	3.6 @ 1	3.5 @ 1	2.9 @ 1
14	1.8	1.5	1.6	1.3	3.7 @ 1	3.7 @ 1	3.4 @ 1	3.0 @ 1
15	1.6	1.5	1.6	1.2	3.8 @ 1	3.9 @ 1	3.5 @ 1	2.9 @ 1
16	1.7	1.4	1.6	1.2	3.8 @ 1	3.7 @ 1	3.2 @ 1	2.8 @ 1

PULL NUMBER 14, ON 101279.
490- 325C,

MG LOSS IN 1 DAYS -- CUMULATIVE LOSS MM.M MG @ DDD DAYS

COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.3	2.2	1.9	2.1	5.6 @ 3	5.9 @ 3	5.2 @ 3	5.8 @ 3
2	2.3	2.3	2.0	1.9	5.7 @ 3	5.8 @ 3	5.3 @ 3	5.2 @ 3
3	2.4	2.2	2.1	2.0	6.0 @ 3	5.5 @ 3	5.1 @ 3	5.3 @ 3
4	2.4	2.3	2.1	2.2	5.9 @ 3	5.9 @ 3	5.1 @ 3	5.1 @ 3
5	2.6	2.3	2.0	2.2	6.2 @ 3	5.7 @ 3	5.3 @ 3	5.0 @ 3
6	2.3	2.2	2.1	2.0	5.7 @ 3	5.4 @ 3	5.1 @ 3	5.9 @ 3
7	2.4	2.2	2.1	2.0	5.8 @ 3	5.5 @ 3	5.1 @ 3	4.9 @ 3
8	2.3	2.2	2.1	2.2	5.9 @ 3	5.3 @ 3	4.8 @ 3	5.1 @ 3
9	2.0	2.1	2.0	2.1	5.6 @ 3	5.2 @ 3	5.0 @ 3	4.6 @ 3
10	2.1	2.1	1.7	2.0	5.9 @ 3	5.6 @ 3	5.1 @ 3	4.3 @ 3
11	2.1	2.3	2.1	2.2	5.7 @ 3	5.7 @ 3	5.3 @ 3	4.8 @ 3
12	2.2	2.1	2.2	2.2	5.9 @ 3	5.3 @ 3	5.3 @ 3	4.8 @ 3
13	1.8	2.3	1.9	2.2	5.5 @ 3	5.9 @ 3	5.4 @ 3	5.2 @ 3
14	2.1	1.9	1.8	2.3	5.9 @ 3	5.6 @ 3	5.2 @ 3	5.3 @ 3
15	1.9	1.8	1.9	2.2	5.7 @ 3	5.7 @ 3	5.3 @ 3	5.2 @ 3
16	2.0	1.8	1.9	2.0	5.7 @ 3	5.5 @ 3	5.1 @ 3	4.7 @ 3

PULL NUMBER 15, ON 102479.
490- 325C,

MG LOSS IN 4 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.2	2.0	1.7	1.7	7.7 @ 7	7.9 @ 7	7.0 @ 7	7.5 @ 7
2	2.2	2.0	1.9	1.5	7.9 @ 7	7.8 @ 7	7.2 @ 7	6.8 @ 7
3	2.1	2.0	2.0	1.5	8.1 @ 7	7.6 @ 7	7.1 @ 7	6.9 @ 7
4	2.1	2.0	2.0	1.8	8.1 @ 7	7.8 @ 7	7.1 @ 7	6.9 @ 7
5	2.1	1.9	2.1	1.9	8.3 @ 7	7.6 @ 7	7.4 @ 7	6.9 @ 7
6	2.0	1.9	2.0	1.9	7.7 @ 7	7.3 @ 7	7.2 @ 7	7.7 @ 7
7	2.2	2.2	2.1	1.8	8.0 @ 7	7.6 @ 7	7.2 @ 7	6.7 @ 7
8	2.1	2.1	2.1	1.9	7.9 @ 7	7.4 @ 7	6.9 @ 7	7.0 @ 7
9	2.1	2.0	1.9	2.1	7.7 @ 7	7.2 @ 7	6.9 @ 7	6.7 @ 7
10	1.9	1.9	1.9	2.0	7.8 @ 7	7.5 @ 7	7.0 @ 7	6.3 @ 7
11	2.1	2.1	1.6	2.0	7.8 @ 7	7.8 @ 7	7.0 @ 7	6.8 @ 7
12	2.1	2.1	1.9	2.1	8.0 @ 7	7.4 @ 7	7.2 @ 7	6.9 @ 7
13	1.9	2.0	1.6	2.0	7.5 @ 7	7.9 @ 7	7.0 @ 7	7.2 @ 7
14	1.9	1.8	1.6	1.7	7.8 @ 7	7.3 @ 7	6.8 @ 7	7.1 @ 7
15	1.9	1.8	1.5	1.7	7.6 @ 7	7.4 @ 7	6.8 @ 7	6.9 @ 7
16	2.1	1.8	1.5	1.8	7.8 @ 7	7.3 @ 7	6.6 @ 7	6.5 @ 7

PULL NUMBER 16, ON 102979.
490- 325C,

MG LOSS IN 1 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	1.5	2.0	1.1	1.4	9.3 @ 9	9.9 @ 9	8.1 @ 9	8.9 @ 9
2	1.3	1.8	1.0	1.0	9.2 @ 9	9.7 @ 9	8.2 @ 9	7.8 @ 9
3	1.4	1.6	1.0	1.0	9.4 @ 9	9.2 @ 9	8.1 @ 9	7.9 @ 9
4	1.3	1.8	1.0	1.0	9.3 @ 9	9.6 @ 9	8.2 @ 9	7.9 @ 9
5	1.3	1.4	0.9	1.0	9.6 @ 9	9.0 @ 9	8.3 @ 9	7.9 @ 9
6	1.3	1.2	1.0	1.2	9.0 @ 9	8.5 @ 9	8.1 @ 9	9.0 @ 9
7	1.3	1.4	1.0	1.2	9.3 @ 9	9.1 @ 9	8.2 @ 9	8.0 @ 9
8	1.6	1.4	0.9	1.6	9.5 @ 9	8.8 @ 9	7.8 @ 9	8.6 @ 9
9	1.2	1.2	1.1	1.4	8.9 @ 9	8.4 @ 9	7.9 @ 9	8.2 @ 9
10	1.1	1.3	1.0	1.8	8.9 @ 9	8.8 @ 9	8.0 @ 9	8.1 @ 9
11	1.1	1.4	0.9	2.0	8.9 @ 9	9.2 @ 9	7.9 @ 9	8.7 @ 9
12	1.3	1.3	1.0	1.9	9.2 @ 9	8.7 @ 9	8.2 @ 9	8.8 @ 9
13	1.3	1.4	1.0	1.9	8.8 @ 9	9.3 @ 9	8.0 @ 9	9.0 @ 9
14	1.2	1.5	0.9	1.4	9.0 @ 9	8.8 @ 9	7.7 @ 9	8.4 @ 9
15	1.4	1.3	0.8	1.1	9.0 @ 9	8.8 @ 9	7.6 @ 9	8.0 @ 9
16	1.6	1.2	0.9	0.8	9.4 @ 9	8.4 @ 9	7.5 @ 9	7.3 @ 9

PULL NUMBER 17, ON 111679.
490- 325C,

MG LOSS IN 16 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.8	3.5	1.2	2.9	12.1 @ 25	13.4 @ 25	9.3 @ 25	11.8 @ 25
2	2.8	3.4	1.0	2.5	12.0 @ 25	13.1 @ 25	9.2 @ 25	10.3 @ 25
3	2.9	3.2	0.9	2.4	12.3 @ 25	12.4 @ 25	9.0 @ 25	10.3 @ 25
4	3.0	3.3	1.0	2.5	12.3 @ 25	13.0 @ 25	9.1 @ 25	10.4 @ 25
5	3.1	3.1	0.9	2.8	12.7 @ 25	12.1 @ 25	9.2 @ 25	10.8 @ 25
6	3.2	3.0	0.9	3.1	12.2 @ 25	11.6 @ 25	9.1 @ 25	12.0 @ 25
7	3.5	3.3	1.3	3.5	12.9 @ 25	12.4 @ 25	9.5 @ 25	11.4 @ 25
8	3.5	3.1	1.4	4.0	13.0 @ 25	12.0 @ 25	9.3 @ 25	12.6 @ 25
9	3.5	2.9	1.7	4.3	12.4 @ 25	11.3 @ 25	9.6 @ 25	12.4 @ 25
10	3.6	3.1	2.2	4.9	12.5 @ 25	11.9 @ 25	10.2 @ 25	13.0 @ 25
11	3.8	3.2	2.9	5.1	12.7 @ 25	12.4 @ 25	10.8 @ 25	13.8 @ 25
12	4.0	3.3	3.4	4.3	13.2 @ 25	11.9 @ 25	11.6 @ 25	13.0 @ 25
13	4.3	3.2	3.5	4.4	13.1 @ 25	12.5 @ 25	11.5 @ 25	13.5 @ 25
14	4.5	3.1	3.8	3.4	13.4 @ 25	11.9 @ 25	11.5 @ 25	11.8 @ 25
15	4.5	3.1	3.7	3.1	13.5 @ 25	11.9 @ 25	11.4 @ 25	11.1 @ 25
16	4.2	2.6	3.4	3.2	13.6 @ 25	11.1 @ 25	10.9 @ 25	10.5 @ 25

PULL NUMBER 18, ON 10780.
490- 325C,

MG LOSS IN 27 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	18.4	17.0	14.4	15.0	30.5 @ 53	30.3 @ 53	23.8 @ 53	26.9 @ 53
2	17.3	16.9	13.9	13.7	29.3 @ 53	30.0 @ 53	23.2 @ 53	24.0 @ 53
3	16.7	13.8	13.0	12.1	29.0 @ 53	26.2 @ 53	22.1 @ 53	22.4 @ 53
4	16.6	15.3	14.3	11.9	28.9 @ 53	28.3 @ 53	23.4 @ 53	22.3 @ 53
5	15.7	14.1	14.9	11.5	28.4 @ 53	26.3 @ 53	24.1 @ 53	22.3 @ 53
6	16.7	12.8	14.1	11.7	28.9 @ 53	24.4 @ 53	23.2 @ 53	23.8 @ 53
7	18.4	13.0	14.6	11.6	31.2 @ 53	25.4 @ 53	24.1 @ 53	23.0 @ 53
8	18.3	12.6	12.5	11.5	31.3 @ 53	24.6 @ 53	21.8 @ 53	24.1 @ 53
9	18.8	12.2	12.0	10.9	31.2 @ 53	23.5 @ 53	21.6 @ 53	23.4 @ 53
10	17.9	12.8	11.4	10.6	30.4 @ 53	24.7 @ 53	21.7 @ 53	23.6 @ 53
11	16.1	13.4	11.3	10.6	28.8 @ 53	25.8 @ 53	22.1 @ 53	24.4 @ 53
12	18.8	13.4	12.3	10.2	32.0 @ 53	25.3 @ 53	23.8 @ 53	23.2 @ 53
13	18.9	14.5	13.7	11.2	32.0 @ 53	27.0 @ 53	25.1 @ 53	24.7 @ 53
14	19.6	16.9	12.9	11.1	33.0 @ 53	28.7 @ 53	24.4 @ 53	23.0 @ 53
15	18.8	17.4	13.0	9.7	32.3 @ 53	29.3 @ 53	24.4 @ 53	20.7 @ 53
16	19.0	15.9	13.2	10.1	32.7 @ 53	26.9 @ 53	24.1 @ 53	20.7 @ 53

PULL NUMBER 19, ON 22680.
490- 325C,

MG LOSS IN 48 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.6	2.5	1.6	1.5	33.1 @102	32.8 @102	25.4 @102	28.4 @102
2	2.5	2.4	1.7	1.4	31.8 @102	32.3 @102	24.9 @102	25.4 @102
3	2.6	2.5	2.0	1.4	31.5 @102	28.6 @102	24.1 @102	23.8 @102
4	2.5	2.6	2.1	1.6	31.5 @102	30.9 @102	25.5 @102	23.9 @102
5	2.7	2.6	2.0	1.7	31.1 @102	28.9 @102	26.1 @102	23.9 @102
6	2.7	2.6	2.1	1.9	31.6 @102	27.0 @102	25.3 @102	25.6 @102
7	2.7	2.5	2.3	1.9	34.0 @102	28.0 @102	26.3 @102	24.9 @102
8	2.7	2.5	2.2	1.9	34.0 @102	27.0 @102	24.0 @102	26.0 @102
9	2.6	2.5	2.2	2.1	33.8 @102	26.0 @102	23.8 @102	25.4 @102
10	2.6	2.3	2.2	2.1	33.1 @102	27.0 @102	23.9 @102	25.8 @102
11	2.5	2.3	2.1	2.2	31.4 @102	28.1 @102	24.2 @102	26.6 @102
12	2.6	2.4	2.2	2.0	34.6 @102	27.7 @102	26.0 @102	25.2 @102
13	2.7	2.3	2.2	2.0	34.7 @102	29.3 @102	27.3 @102	26.7 @102
14	2.7	2.3	2.2	1.6	35.7 @102	31.0 @102	26.6 @102	24.6 @102
15	2.7	2.3	2.2	1.6	35.0 @102	31.6 @102	26.6 @102	22.3 @102
16	4.2	4.8	4.9	5.3	4.2 @-48	4.8 @-48	4.9 @-48	5.3 @-48

PULL NUMBER 20, ON 32080.
490- 325C,

MG LOSS IN 19 DAYS				--	CUMULATIVE LOSS MM.M MG @ DDD DAYS			
COUP	V=136	V= 96	V=65	V=45	V=136	V= 96	V=65	V=45
1	2.1	1.9	0.9	0.7	35.3 @121	34.7 @121	26.3 @121	29.1 @121
2	2.0	1.7	0.9	0.7	33.8 @121	34.0 @121	25.8 @121	26.1 @121
3	2.1	1.6	1.1	0.7	33.6 @121	30.2 @121	25.2 @121	24.5 @121
4	2.0	1.7	1.1	0.8	33.5 @121	32.6 @121	26.6 @121	24.7 @121
5	2.0	1.6	0.9	0.8	33.1 @121	30.5 @121	27.0 @121	24.7 @121
6	1.9	1.6	0.9	0.8	33.5 @121	28.7 @121	26.2 @121	26.5 @121
7	1.9	1.5	1.0	0.8	35.8 @121	29.5 @121	27.4 @121	25.8 @121
8	1.8	1.5	1.0	0.8	35.8 @121	28.5 @121	25.0 @121	26.8 @121
9	1.8	1.4	1.0	0.8	35.6 @121	27.5 @121	24.8 @121	26.3 @121
10	1.7	1.3	1.0	0.8	34.8 @121	28.3 @121	24.9 @121	26.6 @121
11	1.6	1.3	1.0	0.9	32.9 @121	29.5 @121	25.2 @121	27.5 @121
12	1.6	1.4	1.0	0.8	36.2 @121	29.1 @121	27.0 @121	26.0 @121
13	1.7	1.3	1.0	0.8	36.4 @121	30.6 @121	28.3 @121	27.4 @121
14	1.7	1.3	0.9	0.7	37.4 @121	32.3 @121	27.5 @121	25.3 @121
15	1.7	1.2	0.9	0.6	36.7 @121	32.7 @121	27.5 @121	23.0 @121
16	1.9	2.2	1.8	1.6	6.2 @ 68	7.0 @ 68	6.7 @ 68	6.9 @ 68

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 1; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 1- 5

# 1	5PTS	-0.274	5PTS	-0.417	8PTS	-0.174	8PTS	0.674
# 2	5PTS	-0.401	5PTS	-0.195	8PTS	-0.146	8PTS	0.607
# 3	5PTS	-0.193	5PTS	-0.484	8PTS	-0.074	8PTS	0.451
# 4	5PTS	0.037	5PTS	-0.355	8PTS	-0.082	8PTS	0.401
# 5	5PTS	0.017	5PTS	-0.398	8PTS	0.029	8PTS	0.351
# 6	5PTS	-0.474	5PTS	-0.371	8PTS	0.020	8PTS	0.225
# 7	5PTS	-0.390	5PTS	-0.443	8PTS	-0.100	8PTS	0.253
# 8	5PTS	-0.677	5PTS	-0.449	8PTS	-0.101	8PTS	0.309
# 9	5PTS	-0.335	5PTS	-0.409	8PTS	-0.082	8PTS	0.322
#10	5PTS	-0.155	5PTS	-0.236	7PTS	-0.056	7PTS	0.378
#11	5PTS	-0.411	5PTS	-0.437	6PTS	-0.060	6PTS	0.143
#12	5PTS	-0.590	5PTS	-0.477	5PTS	-0.161	5PTS	0.048
#13	4PTS	-0.400	4PTS	-0.274	4PTS	-0.015	4PTS	0.055
#14	3PTS	-0.113	3PTS	-0.034	3PTS	0.016	3PTS	0.137
#15	0PTS	*.	0PTS	*.	0PTS	*.	0PTS	*.
#16	0PTS	*.	0PTS	*.	0PTS	*.	0PTS	*.

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 2; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 1- 5

# 1	5PTS	0.208	5PTS	0.167	8PTS	-0.044	8PTS	-0.218
# 2	5PTS	0.196	5PTS	0.069	8PTS	-0.066	8PTS	-0.152
# 3	5PTS	0.115	5PTS	0.078	8PTS	-0.035	8PTS	-0.088
# 4	5PTS	0.181	5PTS	0.057	8PTS	-0.010	8PTS	-0.064
# 5	5PTS	0.170	5PTS	0.093	8PTS	0.030	8PTS	-0.092
# 6	5PTS	0.294	5PTS	0.079	8PTS	-0.003	8PTS	-0.137
# 7	5PTS	0.252	5PTS	-0.019	8PTS	-0.059	8PTS	-0.068
# 8	5PTS	0.277	5PTS	0.096	8PTS	-0.022	8PTS	-0.129
# 9	5PTS	0.406	5PTS	0.161	8PTS	-0.019	8PTS	-0.057
#10	5PTS	0.494	5PTS	0.050	7PTS	-0.017	7PTS	0.009
#11	5PTS	0.190	5PTS	0.105	6PTS	-0.046	6PTS	-0.175
#12	5PTS	0.178	5PTS	0.119	5PTS	-0.038	5PTS	-0.238
#13	4PTS	0.355	4PTS	0.141	4PTS	0.006	4PTS	-0.136
#14	3PTS	0.208	3PTS	0.063	3PTS	-0.029	3PTS	-0.252
#15	0PTS	*.	0PTS	*.	0PTS	*.	0PTS	*.
#16	4PTS	0.480	4PTS	0.239	7PTS	-0.055	7PTS	0.545

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 3; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 1- 5

# 1	5PTS	0.113	5PTS	0.336	8PTS	0.216	8PTS	-0.171
# 2	5PTS	0.330	5PTS	0.209	8PTS	0.197	8PTS	-0.238
# 3	5PTS	0.146	5PTS	0.438	8PTS	0.163	8PTS	-0.028
# 4	5PTS	-0.115	5PTS	0.401	8PTS	0.156	8PTS	-0.012
# 5	5PTS	-0.137	5PTS	0.371	8PTS	0.104	8PTS	-0.020
# 6	5PTS	0.317	5PTS	0.342	8PTS	0.017	8PTS	0.056
# 7	5PTS	0.408	5PTS	0.589	8PTS	0.047	8PTS	0.027
# 8	5PTS	0.473	5PTS	0.536	8PTS	0.090	8PTS	-0.064
# 9	5PTS	-0.036	5PTS	0.678	8PTS	0.153	8PTS	-0.083
#10	5PTS	-0.303	5PTS	0.570	7PTS	0.150	7PTS	-0.057
#11	5PTS	0.256	5PTS	0.509	6PTS	0.048	6PTS	0.039
#12	5PTS	0.417	5PTS	0.541	5PTS	0.171	5PTS	0.139
#13	4PTS	0.343	4PTS	0.418	4PTS	0.026	4PTS	0.108
#14	3PTS	-0.095	3PTS	-0.029	3PTS	0.013	3PTS	0.115
#15	3PTS	0.153	3PTS	-0.052	6PTS	0.222	6PTS	0.359
#16	4PTS	-0.403	4PTS	-0.061	7PTS	-0.696	7PTS	-0.046

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 4; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 1- 5

# 1	5PTS	0.062	5PTS	0.143	8PTS	0.232	8PTS	-0.548
# 2	5PTS	0.051	5PTS	0.003	8PTS	0.130	8PTS	-0.613
# 3	5PTS	0.003	5PTS	0.327	8PTS	0.108	8PTS	-0.465
# 4	5PTS	-0.281	5PTS	0.115	8PTS	0.105	8PTS	-0.383
# 5	5PTS	-0.173	5PTS	0.191	8PTS	-0.098	8PTS	-0.321
# 6	5PTS	0.052	5PTS	0.200	8PTS	0.052	8PTS	-0.045
# 7	5PTS	-0.238	5PTS	0.186	8PTS	0.291	8PTS	-0.218
# 8	5PTS	0.333	5PTS	0.048	8PTS	0.142	8PTS	-0.135
# 9	5PTS	0.040	5PTS	-0.410	8PTS	0.086	8PTS	-0.226
#10	5PTS	-0.154	5PTS	-0.432	7PTS	0.088	7PTS	-0.454
#11	5PTS	0.208	5PTS	0.042	6PTS	0.169	6PTS	-0.023
#12	5PTS	0.413	5PTS	0.060	5PTS	0.201	5PTS	0.153
#13	4PTS	-0.298	4PTS	-0.284	4PTS	-0.017	4PTS	-0.027
#14	0PTS	*.	0PTS	*.	5PTS	0.124	5PTS	0.266
#15	3PTS	-0.245	3PTS	0.084	6PTS	-0.139	6PTS	-0.215
#16	4PTS	-0.347	4PTS	-0.396	7PTS	-0.832	7PTS	-0.377

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 5; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 1- 5

# 1	5PTS	-0.109	5PTS	-0.228	8PTS	-0.389	8PTS	-0.380
# 2	5PTS	-0.177	5PTS	-0.085	8PTS	-0.244	8PTS	-0.283
# 3	5PTS	-0.071	5PTS	-0.359	8PTS	-0.369	8PTS	-0.413
# 4	5PTS	0.177	5PTS	-0.217	8PTS	-0.355	8PTS	-0.512
# 5	5PTS	0.123	5PTS	-0.258	8PTS	-0.384	8PTS	-0.403
# 6	5PTS	-0.188	5PTS	-0.250	8PTS	-0.358	8PTS	-0.456
# 7	5PTS	-0.041	5PTS	-0.313	8PTS	-0.294	8PTS	-0.368
# 8	5PTS	-0.407	5PTS	-0.231	8PTS	-0.211	8PTS	-0.313
# 9	5PTS	-0.076	5PTS	-0.020	8PTS	-0.296	8PTS	-0.283
#10	5PTS	0.119	5PTS	0.049	7PTS	-0.335	7PTS	-0.410
#11	5PTS	-0.243	5PTS	-0.219	6PTS	-0.137	6PTS	-0.106
#12	5PTS	-0.419	5PTS	-0.244	5PTS	-0.173	5PTS	-0.101
#13	0PTS	*.	0PTS	*.	4PTS	0.136	4PTS	-0.266
#14	0PTS	*.	0PTS	*.	5PTS	-0.408	5PTS	-0.571
#15	3PTS	0.091	3PTS	-0.031	6PTS	-0.385	6PTS	-0.665
#16	4PTS	0.270	4PTS	0.218	7PTS	4.859	7PTS	-0.751

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 6; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 6- 8
FORCE BREAK IN SLOPE AT PULL: 8

# 1	3PTS	-0.394	3PTS	-0.338	8PTS	-0.191	8PTS	-0.194
# 2	3PTS	-0.499	3PTS	-0.294	8PTS	-0.069	8PTS	0.009
# 3	3PTS	-0.527	3PTS	-0.221	8PTS	-0.139	8PTS	-0.220
# 4	3PTS	-0.444	3PTS	-0.191	8PTS	-0.148	8PTS	-0.261
# 5	3PTS	-0.365	3PTS	-0.184	8PTS	-0.089	8PTS	-0.196
# 6	3PTS	-0.326	3PTS	-0.220	8PTS	-0.055	8PTS	-0.295
# 7	3PTS	-0.530	3PTS	-0.228	8PTS	-0.062	8PTS	-0.277
# 8	3PTS	-0.492	3PTS	-0.213	8PTS	-0.061	8PTS	-0.256
# 9	3PTS	-0.560	3PTS	-0.287	8PTS	-0.132	8PTS	-0.316
#10	3PTS	-0.457	3PTS	-0.262	7PTS	-0.147	7PTS	-0.218
#11	3PTS	-0.350	3PTS	-0.278	6PTS	0.025	6PTS	0.123
#12	3PTS	-0.482	3PTS	-0.224	3PTS	-0.183	3PTS	-0.418
#13	3PTS	-0.764	3PTS	-0.494	4PTS	-0.364	4PTS	-0.090
#14	3PTS	-0.883	3PTS	-0.410	5PTS	-0.075	5PTS	-0.395
#15	0PTS	*.	0PTS	*.	6PTS	-0.119	6PTS	-0.351
#16	0PTS	*.	0PTS	*.	7PTS	-1.179	7PTS	-0.553

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 7; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 6- 8
FORCE BREAK IN SLOPE AT PULL: 8

# 1	3PTS	0.779	3PTS	0.667	8PTS	0.634	8PTS	1.028
# 2	3PTS	0.986	3PTS	0.580	8PTS	0.603	8PTS	1.238
# 3	3PTS	1.042	3PTS	0.436	8PTS	0.512	8PTS	0.738
# 4	3PTS	0.877	3PTS	0.379	8PTS	0.419	8PTS	0.796
# 5	3PTS	0.721	3PTS	0.364	8PTS	0.475	8PTS	0.789
# 6	3PTS	0.645	3PTS	0.435	8PTS	0.488	8PTS	0.674
# 7	3PTS	1.047	3PTS	0.450	8PTS	0.421	8PTS	0.694
# 8	3PTS	0.971	3PTS	0.421	8PTS	0.402	8PTS	0.688
# 9	3PTS	1.106	3PTS	0.567	8PTS	0.430	8PTS	0.637
#10	3PTS	0.902	3PTS	0.517	7PTS	0.316	7PTS	0.753
#11	3PTS	0.691	3PTS	0.548	0PTS	*.	0PTS	*.
#12	3PTS	0.952	3PTS	0.442	3PTS	0.362	3PTS	0.826
#13	3PTS	1.509	3PTS	0.976	4PTS	0.372	4PTS	0.859
#14	3PTS	1.744	3PTS	0.811	5PTS	0.551	5PTS	0.866
#15	0PTS	*.	0PTS	*.	6PTS	0.445	6PTS	1.092
#16	0PTS	*.	0PTS	*.	7PTS	-0.666	7PTS	0.939

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 8; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 6- 8
FORCE BREAK IN SLOPE AT PULL: 8

# 1	3PTS	-0.384	3PTS	-0.329	8PTS	-0.283	8PTS	-0.190
# 2	3PTS	-0.487	3PTS	-0.286	8PTS	-0.404	8PTS	-0.568
# 3	3PTS	-0.514	3PTS	-0.215	8PTS	-0.165	8PTS	0.025
# 4	3PTS	-0.433	3PTS	-0.187	8PTS	-0.085	8PTS	0.035
# 5	3PTS	-0.356	3PTS	-0.180	8PTS	-0.066	8PTS	-0.109
# 6	3PTS	-0.318	3PTS	-0.215	8PTS	-0.161	8PTS	-0.022
# 7	3PTS	-0.517	3PTS	-0.222	8PTS	-0.244	8PTS	-0.045
# 8	3PTS	-0.479	3PTS	-0.208	8PTS	-0.239	8PTS	-0.099
# 9	3PTS	-0.546	3PTS	-0.280	8PTS	-0.140	8PTS	0.006
#10	3PTS	-0.445	3PTS	-0.255	7PTS	-4.725	7PTS	-4.389
#11	3PTS	-0.341	3PTS	-0.271	0PTS	*.	0PTS	*.
#12	3PTS	-0.470	3PTS	-0.218	3PTS	-0.179	3PTS	-0.408
#13	3PTS	-0.745	3PTS	-0.482	4PTS	-0.144	4PTS	-0.502
#14	3PTS	-0.861	3PTS	-0.400	5PTS	-0.191	5PTS	-0.166
#15	3PTS	-6.377	3PTS	-1.619	6PTS	-0.024	6PTS	-0.219
#16	0PTS	*.	0PTS	*.	7PTS	-1.431	7PTS	0.243

* INDICATES NO PREDICTION;LESS THAN 3 PTS

TEST PERIOD BETWEEN PULLS # 8-11
FORCE BREAK IN SLOPE AT PULL: 8

# 1	4PTS	0.653	4PTS	0.387	4PTS	0.417	4PTS	0.779
# 2	4PTS	0.663	4PTS	0.294	4PTS	0.397	4PTS	0.776
# 3	4PTS	0.132	4PTS	0.308	4PTS	0.357	4PTS	0.634
# 4	4PTS	0.558	4PTS	0.319	4PTS	0.304	4PTS	0.707
# 5	4PTS	0.516	4PTS	0.319	4PTS	0.378	4PTS	0.577
# 6	4PTS	0.503	4PTS	0.330	4PTS	0.380	4PTS	0.618
# 7	4PTS	0.522	4PTS	0.326	3PTS	0.095	3PTS	0.217
# 8	4PTS	0.481	4PTS	0.266	8PTS	-0.239	8PTS	-0.099
# 9	4PTS	0.525	4PTS	0.246	8PTS	-0.140	8PTS	0.006
#10	4PTS	0.518	4PTS	0.236	4PTS	0.559	4PTS	0.901
#11	4PTS	0.493	4PTS	0.244	4PTS	0.471	4PTS	0.792
#12	3PTS	0.173	3PTS	-0.183	4PTS	0.368	4PTS	0.702
#13	3PTS	-0.745	3PTS	-0.482	4PTS	0.436	4PTS	0.795
#14	3PTS	-0.861	3PTS	-0.400	4PTS	0.375	4PTS	0.734
#15	4PTS	0.636	4PTS	0.126	4PTS	0.310	4PTS	0.750
#16	4PTS	0.556	4PTS	-0.017	4PTS	0.287	4PTS	0.577

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL # 9: DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 8-11
FORCE BREAK IN SLOPE AT PULL: 8

# 1	4PTS	-0.263	4PTS	0.016	4PTS	-0.144	4PTS	-0.463
# 2	4PTS	-0.261	4PTS	0.067	4PTS	-0.153	4PTS	-0.403
# 3	4PTS	0.329	4PTS	0.046	4PTS	-0.127	4PTS	-0.358
# 4	4PTS	-0.300	4PTS	0.041	4PTS	-0.100	4PTS	-0.415
# 5	4PTS	-0.261	4PTS	0.069	4PTS	-0.168	4PTS	-0.284
# 6	4PTS	-0.266	4PTS	0.047	4PTS	-0.154	4PTS	-0.345
# 7	4PTS	-0.255	4PTS	0.073	3PTS	-0.141	3PTS	-0.321
# 8	4PTS	-0.222	4PTS	0.141	0PTS	*.	0PTS	*.
# 9	4PTS	-0.303	4PTS	0.147	3PTS	0.662	3PTS	0.822
#10	4PTS	-0.334	4PTS	0.153	4PTS	-0.218	4PTS	-0.381
#11	4PTS	-0.303	4PTS	0.210	4PTS	-0.160	4PTS	-0.390
#12	3PTS	-0.256	3PTS	0.270	4PTS	-0.084	4PTS	-0.298
#13	0PTS	*.	0PTS	*.	4PTS	-0.160	4PTS	-0.432
#14	3PTS	0.918	3PTS	1.191	4PTS	-0.157	4PTS	-0.382
#15	4PTS	-0.319	4PTS	0.556	4PTS	-0.084	4PTS	-0.407
#16	4PTS	-0.394	4PTS	0.539	4PTS	-0.073	4PTS	-0.227

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #10: DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 8-11
FORCE BREAK IN SLOPE AT PULL: 8

# 1	4PTS	-1.055	4PTS	-0.959	4PTS	-0.720	4PTS	-0.967
# 2	4PTS	-1.081	4PTS	-0.836	4PTS	-0.654	4PTS	-1.077
# 3	4PTS	-0.956	4PTS	-0.828	4PTS	-0.608	4PTS	-0.823
# 4	4PTS	-0.755	4PTS	-0.843	4PTS	-0.535	4PTS	-0.887
# 5	4PTS	-0.729	4PTS	-0.900	4PTS	-0.580	4PTS	-0.832
# 6	4PTS	-0.687	4PTS	-0.885	4PTS	-0.611	4PTS	-0.812
# 7	4PTS	-0.757	4PTS	-0.924	3PTS	0.046	3PTS	0.104
# 8	4PTS	-0.721	4PTS	-0.913	0PTS	*.	0PTS	*.
# 9	4PTS	-0.670	4PTS	-0.874	3PTS	-1.289	3PTS	-1.601
#10	4PTS	-0.592	4PTS	-0.862	4PTS	-0.917	4PTS	-1.418
#11	4PTS	-0.594	4PTS	-0.993	4PTS	-0.820	4PTS	-1.140
#12	3PTS	0.083	3PTS	-0.087	4PTS	-0.719	4PTS	-1.102
#13	0PTS	*.	0PTS	*.	4PTS	-0.734	4PTS	-1.066
#14	3PTS	-1.788	3PTS	-2.318	4PTS	-0.594	4PTS	-1.016
#15	4PTS	-0.904	4PTS	-1.384	4PTS	-0.580	4PTS	-1.005
#16	4PTS	-0.567	4PTS	-1.009	4PTS	-0.547	4PTS	-0.940

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #11: DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS # 8-11
FORCE BREAK IN SLOPE AT PULL: 8

# 1	4PTS	0.664	4PTS	0.556	4PTS	0.447	4PTS	0.651
# 2	4PTS	0.680	4PTS	0.474	4PTS	0.410	4PTS	0.704
# 3	4PTS	0.495	4PTS	0.474	4PTS	0.378	4PTS	0.547
# 4	4PTS	0.497	4PTS	0.484	4PTS	0.331	4PTS	0.595
# 5	4PTS	0.475	4PTS	0.512	4PTS	0.370	4PTS	0.538
# 6	4PTS	0.451	4PTS	0.507	4PTS	0.386	4PTS	0.538
# 7	4PTS	0.489	4PTS	0.525	0PTS	*.	0PTS	*.
# 8	4PTS	0.462	4PTS	0.506	0PTS	*.	0PTS	*.
# 9	4PTS	0.448	4PTS	0.482	3PTS	0.627	3PTS	0.779
#10	4PTS	0.408	4PTS	0.474	4PTS	0.576	4PTS	0.899
#11	4PTS	0.403	4PTS	0.540	4PTS	0.508	4PTS	0.738
#12	0PTS	*.	0PTS	*.	4PTS	0.435	4PTS	0.699
#13	0PTS	*.	0PTS	*.	4PTS	0.458	4PTS	0.703
#14	3PTS	0.869	3PTS	1.127	4PTS	0.376	4PTS	0.664
#15	4PTS	0.587	4PTS	0.702	4PTS	0.354	4PTS	0.663
#16	4PTS	0.405	4PTS	0.497	4PTS	0.333	4PTS	0.591

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #12; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #12-18
FORCE BREAK IN SLOPE AT PULL: 18

# 1	7PTS	1.261	7PTS	1.482	7PTS	1.503	7PTS	1.424
# 2	7PTS	1.301	7PTS	1.724	7PTS	1.370	7PTS	1.499
# 3	7PTS	1.497	7PTS	1.831	7PTS	1.710	7PTS	1.684
# 4	7PTS	1.455	7PTS	1.689	7PTS	1.767	7PTS	1.614
# 5	7PTS	1.770	7PTS	1.597	7PTS	1.737	7PTS	1.672
# 6	7PTS	1.335	7PTS	1.655	7PTS	1.680	7PTS	1.747
# 7	7PTS	1.319	7PTS	1.693	7PTS	1.680	7PTS	1.703
# 8	7PTS	1.336	7PTS	1.816	7PTS	1.862	7PTS	1.786
# 9	7PTS	1.070	7PTS	1.969	7PTS	1.865	7PTS	1.723
#10	7PTS	1.351	7PTS	2.098	7PTS	1.707	7PTS	1.644
#11	7PTS	1.608	7PTS	1.817	7PTS	1.952	7PTS	1.805
#12	7PTS	1.575	7PTS	1.842	7PTS	2.016	7PTS	1.669
#13	7PTS	1.156	7PTS	1.614	7PTS	1.899	7PTS	1.786
#14	7PTS	1.270	7PTS	1.486	7PTS	1.830	7PTS	1.248
#15	7PTS	1.149	7PTS	1.490	7PTS	1.863	7PTS	1.110
#16	7PTS	1.270	7PTS	1.502	7PTS	1.624	7PTS	1.217

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #13; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #12-18
FORCE BREAK IN SLOPE AT PULL: 18

# 1	7PTS	0.368	7PTS	0.235	7PTS	0.299	7PTS	0.443
# 2	7PTS	0.426	7PTS	0.324	7PTS	0.255	7PTS	0.476
# 3	7PTS	0.514	7PTS	0.523	7PTS	0.381	7PTS	0.681
# 4	7PTS	0.527	7PTS	0.454	7PTS	0.631	7PTS	0.621
# 5	7PTS	0.678	7PTS	0.304	7PTS	0.735	7PTS	0.605
# 6	7PTS	0.414	7PTS	0.464	7PTS	0.614	7PTS	0.638
# 7	7PTS	0.430	7PTS	0.466	7PTS	0.610	7PTS	0.725
# 8	7PTS	0.331	7PTS	0.592	7PTS	0.830	7PTS	0.774
# 9	7PTS	0.081	7PTS	0.487	7PTS	0.829	7PTS	0.704
#10	7PTS	0.055	7PTS	0.320	7PTS	0.848	7PTS	0.568
#11	7PTS	0.269	7PTS	0.516	7PTS	0.999	7PTS	0.717
#12	7PTS	0.054	7PTS	0.583	7PTS	1.076	7PTS	0.626
#13	7PTS	-0.156	7PTS	0.154	7PTS	0.947	7PTS	0.590
#14	7PTS	-0.100	7PTS	0.219	7PTS	0.799	7PTS	0.077
#15	7PTS	-0.085	7PTS	0.153	7PTS	0.884	7PTS	-0.051
#16	7PTS	0.019	7PTS	0.180	7PTS	0.660	7PTS	0.094

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #14; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #12-18
FORCE BREAK IN SLOPE AT PULL: 18

# 1	7PTS	-1.140	7PTS	-1.083	7PTS	-1.094	7PTS	-1.028
# 2	7PTS	-1.096	7PTS	-1.073	7PTS	-1.090	7PTS	-1.060
# 3	7PTS	-1.147	7PTS	-1.018	7PTS	-1.062	7PTS	-0.874
# 4	7PTS	-1.161	7PTS	-1.058	7PTS	-1.000	7PTS	-1.007
# 5	7PTS	-1.198	7PTS	-1.077	7PTS	-0.876	7PTS	-1.037
# 6	7PTS	-1.141	7PTS	-1.057	7PTS	-0.826	7PTS	-0.984
# 7	7PTS	-1.216	7PTS	-1.068	7PTS	-0.801	7PTS	-0.785
# 8	7PTS	-1.190	7PTS	-0.916	7PTS	-0.772	7PTS	-0.833
# 9	7PTS	-1.146	7PTS	-0.967	7PTS	-0.625	7PTS	-0.840
#10	7PTS	-1.272	7PTS	-0.858	7PTS	-0.482	7PTS	-0.897
#11	7PTS	-1.137	7PTS	-1.007	7PTS	-0.570	7PTS	-0.900
#12	7PTS	-1.308	7PTS	-0.965	7PTS	-0.563	7PTS	-0.854
#13	7PTS	-1.167	7PTS	-1.109	7PTS	-0.659	7PTS	-1.059
#14	7PTS	-1.358	7PTS	-0.981	7PTS	-0.891	7PTS	-1.099
#15	7PTS	-1.162	7PTS	-1.093	7PTS	-0.844	7PTS	-1.122
#16	7PTS	-1.107	7PTS	-1.067	7PTS	-0.788	7PTS	-1.049

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #15; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #12-18
FORCE BREAK IN SLOPE AT PULL: 18

# 1	7PTS -1.057	7PTS -1.159	7PTS -0.864	7PTS -0.767
# 2	7PTS -1.170	7PTS -1.370	7PTS -0.912	7PTS -0.888
# 3	7PTS -1.167	7PTS -1.483	7PTS -1.009	7PTS -0.996
# 4	7PTS -1.191	7PTS -1.441	7PTS -1.168	7PTS -0.899
# 5	7PTS -1.276	7PTS -1.447	7PTS -1.178	7PTS -1.033
# 6	7PTS -1.032	7PTS -1.450	7PTS -1.014	7PTS -1.100
# 7	7PTS -1.105	7PTS -1.464	7PTS -0.948	7PTS -1.093
# 8	7PTS -0.950	7PTS -1.462	7PTS -0.887	7PTS -1.110
# 9	7PTS -0.944	7PTS -1.318	7PTS -0.971	7PTS -1.176
#10	7PTS -0.955	7PTS -1.244	7PTS -0.637	7PTS -0.991
#11	7PTS -1.084	7PTS -1.062	7PTS -0.710	7PTS -1.152
#12	7PTS -1.039	7PTS -1.147	7PTS -0.894	7PTS -1.106
#13	7PTS -0.717	7PTS -0.887	7PTS -0.811	7PTS -1.135
#14	7PTS -0.831	7PTS -0.840	7PTS -0.969	7PTS -0.766
#15	7PTS -0.672	7PTS -0.814	7PTS -1.087	7PTS -0.761
#16	7PTS -0.781	7PTS -0.850	7PTS -1.041	7PTS -0.906

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #16; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #12-18
FORCE BREAK IN SLOPE AT PULL: 18

# 1	7PTS -1.762	7PTS -1.619	7PTS -1.576	7PTS -1.921
# 2	7PTS -1.654	7PTS -1.740	7PTS -1.288	7PTS -1.904
# 3	7PTS -1.741	7PTS -1.872	7PTS -1.431	7PTS -1.923
# 4	7PTS -1.659	7PTS -1.854	7PTS -1.593	7PTS -1.959
# 5	7PTS -1.819	7PTS -1.718	7PTS -1.611	7PTS -1.753
# 6	7PTS -1.552	7PTS -1.803	7PTS -1.599	7PTS -1.656
# 7	7PTS -1.580	7PTS -1.809	7PTS -1.549	7PTS -1.832
# 8	7PTS -1.639	7PTS -1.813	7PTS -1.840	7PTS -1.884
# 9	7PTS -1.295	7PTS -1.791	7PTS -1.741	7PTS -1.694
#10	7PTS -1.248	7PTS -1.696	7PTS -1.800	7PTS -1.621
#11	7PTS -1.384	7PTS -1.415	7PTS -1.981	7PTS -1.846
#12	7PTS -1.401	7PTS -1.495	7PTS -2.102	7PTS -1.699
#13	7PTS -1.152	7PTS -1.164	7PTS -1.976	7PTS -1.774
#14	7PTS -1.101	7PTS -1.056	7PTS -1.707	7PTS -1.457
#15	7PTS -1.182	7PTS -0.962	7PTS -1.627	7PTS -1.277
#16	7PTS -1.450	7PTS -1.117	7PTS -1.320	7PTS -1.346

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #17; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #12-18
FORCE BREAK IN SLOPE AT PULL: 18

# 1	7PTS 3.551	7PTS 3.216	7PTS 2.518	7PTS 2.669
# 2	7PTS 3.302	7PTS 3.113	7PTS 2.466	7PTS 2.695
# 3	7PTS 2.989	7PTS 2.833	7PTS 1.919	7PTS 1.824
# 4	7PTS 2.980	7PTS 3.209	7PTS 1.751	7PTS 2.210
# 5	7PTS 2.558	7PTS 3.493	7PTS 1.433	7PTS 2.078
# 6	7PTS 2.949	7PTS 3.186	7PTS 1.384	7PTS 1.732
# 7	7PTS 3.252	7PTS 3.163	7PTS 1.156	7PTS 1.559
# 8	7PTS 3.196	7PTS 2.415	7PTS 0.705	7PTS 1.504
# 9	7PTS 3.535	7PTS 2.141	7PTS 0.415	7PTS 1.578
#10	7PTS 3.217	7PTS 1.736	7PTS -0.042	7PTS 1.666
#11	7PTS 2.511	7PTS 1.423	7PTS -0.223	7PTS 1.712
#12	7PTS 3.243	7PTS 1.441	7PTS -0.003	7PTS 1.745
#13	7PTS 3.249	7PTS 1.987	7PTS 0.299	7PTS 2.131
#14	7PTS 3.381	7PTS 1.625	7PTS 0.965	7PTS 3.080
#15	7PTS 3.093	7PTS 1.753	7PTS 0.726	7PTS 3.329
#16	7PTS 3.173	7PTS 1.938	7PTS 0.935	7PTS 3.070

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #18; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #12-18
FORCE BREAK IN SLOPE AT PULL: 18

# 1	7PTS	-1.222	7PTS	-1.073	7PTS	-0.786	7PTS	-0.819
# 2	7PTS	-1.109	7PTS	-0.978	7PTS	-0.801	7PTS	-0.818
# 3	7PTS	-0.945	7PTS	-0.814	7PTS	-0.508	7PTS	-0.397
# 4	7PTS	-0.950	7PTS	-0.998	7PTS	-0.387	7PTS	-0.581
# 5	7PTS	-0.713	7PTS	-1.152	7PTS	-0.238	7PTS	-0.533
# 6	7PTS	-0.973	7PTS	-0.995	7PTS	-0.239	7PTS	-0.378
# 7	7PTS	-1.100	7PTS	-0.981	7PTS	-0.148	7PTS	-0.278
# 8	7PTS	-1.084	7PTS	-0.633	7PTS	0.102	7PTS	-0.239
# 9	7PTS	-1.301	7PTS	-0.521	7PTS	0.228	7PTS	-0.296
#10	7PTS	-1.149	7PTS	-0.355	7PTS	0.405	7PTS	-0.369
#11	7PTS	-0.783	7PTS	-0.272	7PTS	0.532	7PTS	-0.335
#12	7PTS	-1.124	7PTS	-0.259	7PTS	0.469	7PTS	-0.382
#13	7PTS	-1.213	7PTS	-0.595	7PTS	0.301	7PTS	-0.540
#14	7PTS	-1.262	7PTS	-0.452	7PTS	-0.028	7PTS	-1.083
#15	7PTS	-1.141	7PTS	-0.526	7PTS	0.085	7PTS	-1.228
#16	7PTS	-1.125	7PTS	-0.586	7PTS	-0.070	7PTS	-1.080

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #18; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #18-20
FORCE BREAK IN SLOPE AT PULL: 18

# 1	3PTS	-0.141	3PTS	-0.034	3PTS	-0.018	3PTS	-0.110
# 2	3PTS	-0.125	3PTS	-0.022	3PTS	-0.014	3PTS	-0.093
# 3	3PTS	-0.135	3PTS	-0.037	3PTS	-0.014	3PTS	-0.076
# 4	3PTS	-0.127	3PTS	-0.036	3PTS	-0.015	3PTS	-0.079
# 5	3PTS	-0.122	3PTS	-0.012	3PTS	-0.009	3PTS	-0.071
# 6	3PTS	-0.106	3PTS	-0.010	3PTS	-0.009	3PTS	-0.075
# 7	3PTS	-0.098	3PTS	-0.017	3PTS	-0.011	3PTS	-0.066
# 8	3PTS	-0.093	3PTS	-0.008	3PTS	-0.009	3PTS	-0.060
# 9	3PTS	-0.099	3PTS	-0.020	3PTS	-0.001	3PTS	-0.050
#10	3PTS	-0.082	3PTS	-0.017	3PTS	0.003	3PTS	-0.050
#11	3PTS	-0.068	3PTS	-0.018	3PTS	0.005	3PTS	-0.048
#12	3PTS	-0.072	3PTS	-0.019	3PTS	-0.000	3PTS	-0.057
#13	3PTS	-0.074	3PTS	-0.012	3PTS	0.003	3PTS	-0.047
#14	3PTS	-0.084	3PTS	-0.001	3PTS	-0.004	3PTS	-0.043
#15	3PTS	-0.080	3PTS	0.005	3PTS	0.004	3PTS	-0.034
#16	7PTS	-1.125	7PTS	-0.586	7PTS	-0.070	7PTS	-1.080

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #19; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #18-20
FORCE BREAK IN SLOPE AT PULL: 18

# 1	3PTS	0.488	3PTS	0.120	3PTS	0.062	3PTS	0.393
# 2	3PTS	0.435	3PTS	0.076	3PTS	0.049	3PTS	0.324
# 3	3PTS	0.468	3PTS	0.130	3PTS	0.047	3PTS	0.264
# 4	3PTS	0.441	3PTS	0.126	3PTS	0.052	3PTS	0.273
# 5	3PTS	0.422	3PTS	0.043	3PTS	0.032	3PTS	0.245
# 6	3PTS	0.369	3PTS	0.035	3PTS	0.030	3PTS	0.259
# 7	3PTS	0.342	3PTS	0.059	3PTS	0.037	3PTS	0.229
# 8	3PTS	0.324	3PTS	0.026	3PTS	0.031	3PTS	0.209
# 9	3PTS	0.343	3PTS	0.070	3PTS	0.005	3PTS	0.175
#10	3PTS	0.285	3PTS	0.060	3PTS	-0.011	3PTS	0.174
#11	3PTS	0.238	3PTS	0.062	3PTS	-0.016	3PTS	0.167
#12	3PTS	0.249	3PTS	0.067	3PTS	0.001	3PTS	0.199
#13	3PTS	0.257	3PTS	0.043	3PTS	-0.010	3PTS	0.165
#14	3PTS	0.291	3PTS	0.004	3PTS	0.015	3PTS	0.151
#15	3PTS	0.279	3PTS	-0.018	3PTS	-0.013	3PTS	0.118
#16	0PTS	*.	0PTS	*.	0PTS	*.	0PTS	*.

* INDICATES NO PREDICTION;LESS THAN 3 PTS

DEVIATIONS, MG/COUPON (LS PREDICT-DATA)
PULL #20; DEVIATIONS FROM LEAST SQUARE LINES.
TEST PERIOD BETWEEN PULLS #18-20
FORCE BREAK IN SLOPE AT PULL: 18

# 1	3PTS	-0.348	3PTS	-0.085	3PTS	-0.044	3PTS	-0.273
# 2	3PTS	-0.310	3PTS	-0.054	3PTS	-0.035	3PTS	-0.231
# 3	3PTS	-0.333	3PTS	-0.092	3PTS	-0.034	3PTS	-0.188
# 4	3PTS	-0.314	3PTS	-0.090	3PTS	-0.037	3PTS	-0.194
# 5	3PTS	-0.300	3PTS	-0.030	3PTS	-0.023	3PTS	-0.175
# 6	3PTS	-0.263	3PTS	-0.025	3PTS	-0.021	3PTS	-0.184
# 7	3PTS	-0.243	3PTS	-0.042	3PTS	-0.026	3PTS	-0.163
# 8	3PTS	-0.230	3PTS	-0.019	3PTS	-0.022	3PTS	-0.149
# 9	3PTS	-0.244	3PTS	-0.050	3PTS	-0.003	3PTS	-0.124
#10	3PTS	-0.203	3PTS	-0.043	3PTS	0.008	3PTS	-0.124
#11	3PTS	-0.169	3PTS	-0.044	3PTS	0.011	3PTS	-0.119
#12	3PTS	-0.177	3PTS	-0.048	3PTS	-0.001	3PTS	-0.142
#13	3PTS	-0.183	3PTS	-0.030	3PTS	0.007	3PTS	-0.117
#14	3PTS	-0.207	3PTS	-0.003	3PTS	-0.010	3PTS	-0.107
#15	3PTS	-0.198	3PTS	0.013	3PTS	0.010	3PTS	-0.084
#16	0PTS	*.	0PTS	*.	0PTS	*.	0PTS	*.

* INDICATES NO PREDICTION;LESS THAN 3 PTS

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RANGE(2)=    0.
   IF NON-NEGATIVE, PLOT W VS T
   IF -.5,PLOT W VS SQRT(T); IF -1, PLOT LOG(W) VS LOG(T)
   IF -1.5, PLOT W VS (T & SQRT(T)); IF -2, PLOT W**2 VS T
FOLLOWING HEADINGS APPLY FOR W VS T:
FOLLOWING SLOPE IS  UGRAMS/M2/SECOND.
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TSECT	COUP	FROM	TO	PTS	SLOPE	SDEV	INTCPT	SDEV
1	1	1	5	5	3.2885+	0.056	6.697+	0.402
1	1	6	8	3	5.2362+	0.863	7.904+	2.445
1	1	8	11	4	1.0299+	0.224	27.325+	2.348
1	1	12	18	7	11.6319+	1.036	5.907+	2.054
1	1	18	20	3	1.5663+	0.292	54.636+	2.444
1	2	1	5	5	3.1689+	0.085	5.997+	0.612
1	2	6	8	3	5.1271+	1.094	8.095+	3.101
1	2	8	11	4	0.8343+	0.229	28.100+	2.399
1	2	12	18	7	11.0294+	0.985	6.411+	1.954
1	2	18	20	3	1.4899+	0.260	52.510+	2.177
1	3	1	5	5	2.6887+	0.040	6.051+	0.290
1	3	6	8	3	4.9737+	1.156	7.719+	3.276
1	3	8	11	4	0.9338+	0.177	25.658+	1.858
1	3	12	18	7	10.8563+	0.952	6.908+	1.888
1	3	18	20	3	1.5372+	0.280	51.634+	2.342
1	4	1	5	5	2.9709+	0.058	11.407+	0.416
1	4	6	8	3	4.8750+	0.973	6.315+	2.758
1	4	8	11	4	0.8640+	0.173	24.838+	1.810
1	4	12	18	7	10.8492+	0.943	6.834+	1.870
1	4	18	20	3	1.5062+	0.264	51.697+	2.207
1	5	1	5	5	2.7779+	0.044	10.145+	0.319
1	5	6	8	3	4.2882+	0.800	7.068+	2.267
1	5	8	11	4	0.8572+	0.164	22.962+	1.714
1	5	12	18	7	10.6028+	0.925	7.397+	1.834
1	5	18	20	3	1.5498+	0.252	50.448+	2.110
1	6	1	5	5	2.7098+	0.097	4.582+	0.702
1	6	6	8	3	4.1665+	0.715	6.446+	2.027
1	6	8	11	4	0.8328+	0.156	21.835+	1.640
1	6	12	18	7	10.9251+	0.907	6.337+	1.799
1	6	18	20	3	1.5431+	0.221	51.470+	1.846
1	7	1	5	5	3.7395+	0.095	8.765+	0.688
1	7	6	8	3	4.9494+	1.161	6.608+	3.291
1	7	8	11	4	0.8869+	0.168	25.440+	1.758
1	7	12	18	7	11.9451+	0.975	6.171+	1.933
1	7	18	20	3	1.5305+	0.204	56.352+	1.710
1	8	1	5	5	3.0879+	0.148	4.220+	1.065
1	8	6	8	3	4.8226+	1.078	7.302+	3.053
1	8	8	11	4	0.8793+	0.158	25.484+	1.652
1	8	12	18	7	11.9458+	0.958	6.377+	1.901
1	8	18	20	3	1.4924+	0.194	56.714+	1.619
1	9	1	5	5	2.7239+	0.078	5.201+	0.560
1	9	6	8	3	4.9640+	1.227	5.727+	3.477
1	9	8	11	4	0.8824+	0.158	24.703+	1.654
1	9	12	18	7	11.9140+	0.983	5.834+	1.949
1	9	18	20	3	1.4611+	0.205	56.598+	1.718
1	10	1	5	5	2.6125+	0.092	4.567+	0.661
1	10	6	8	3	4.9182+	1.001	5.888+	2.836
1	10	8	11	4	0.8663+	0.148	24.522+	1.552
1	10	12	18	7	11.5539+	0.940	6.258+	1.864
1	10	18	20	3	1.4603+	0.171	55.088+	1.428
1	11	1	5	5	2.4633+	0.089	5.101+	0.640
1	11	6	8	3	4.4033+	0.767	5.720+	2.174
1	11	8	11	4	0.8227+	0.144	22.152+	1.512

FLUX in $ug/m^2/s$

SUMMARY OF FLUXES (continued on following pages.)

TSECT	COUP	FROM	TO	PTS	SLOPE	SDEV	INTCPT	SDEV
1	11	12	18	7	10.9535+	0.837	6.438+	1.661
1	11	18	20	3	1.3858+	0.142	52.119+	1.189
1	12	1	5	5	2.7636+	0.138	4.854+	0.993
1	12	6	8	3	4.8583+	1.056	5.461+	2.992
1	12	8	10	3	1.1588+	0.129	21.994+	1.003
1	12	12	18	7	12.3087+	0.977	5.994+	1.938
1	12	18	20	3	1.4253+	0.149	58.445+	1.245
1	13	1	4	4	3.0898+	0.222	5.621+	1.166
1	13	6	8	3	6.0884+	1.674	5.019+	4.743
1	13	12	18	7	12.3453+	0.913	5.636+	1.811
1	13	18	20	3	1.4745+	0.154	58.205+	1.285
1	14	1	3	3	3.5834+	0.203	12.113+	0.801
1	14	6	8	3	6.6740+	1.935	4.475+	5.483
1	14	9	11	3	2.4760+	0.649	21.427+	5.260
1	14	12	18	7	12.7516+	0.961	5.768+	1.907
1	14	18	20	3	1.4716+	0.174	60.308+	1.456
1	15	3	5	3	4.4103+	0.129	6.935+	0.739
*** I M S L(UERTST) ***		WARNING			RLMUL		2 (IER =	34)
1	15	6	8	3	3.6267+	0.	9.642+	0.
1	15	8	11	4	1.0937+	0.202	28.002+	1.679
1	15	12	18	7	12.4629+	0.879	5.873+	1.744
1	15	18	20	3	1.4634+	0.167	58.877+	1.394
1	16	2	5	4	3.6995+	0.170	10.807+	1.074
1	16	8	11	4	0.9626+	0.153	29.083+	1.472
1	16	12	18	7	12.5798+	0.921	6.093+	1.827
2	1	1	5	5	2.0299+	0.090	5.867+	0.651
2	1	6	8	3	4.8477+	0.740	7.974+	2.098
2	1	8	11	4	0.6233+	0.184	26.815+	1.926
2	1	12	18	7	8.6696+	0.974	6.140+	1.932
2	1	18	20	3	0.8463+	0.072	44.417+	0.599
2	2	1	5	5	2.2101+	0.044	10.144+	0.320
2	2	6	8	3	4.2307+	0.644	8.583+	1.823
2	2	8	11	4	0.4947+	0.158	25.137+	1.652
2	2	12	18	7	8.4110+	0.997	6.324+	1.977
2	2	18	20	3	0.8848+	0.045	43.061+	0.379
2	3	1	5	5	1.9580+	0.119	4.700+	0.856
2	3	6	8	3	4.2449+	0.484	8.184+	1.370
2	3	8	11	4	0.5984+	0.157	24.625+	1.647
2	3	12	18	7	8.0137+	0.978	6.255+	1.940
2	3	18	20	3	1.0479+	0.077	40.035+	0.648
2	4	1	5	5	1.9644+	0.086	5.190+	0.620
2	4	6	8	3	4.3905+	0.420	7.879+	1.189
2	4	8	11	4	0.5415+	0.160	24.747+	1.680
2	4	12	18	7	8.5766+	1.027	5.962+	2.036
2	4	18	20	3	1.0954+	0.076	42.502+	0.632
2	5	1	5	5	1.9442+	0.093	5.168+	0.669
2	5	6	8	3	4.4334+	0.404	7.697+	1.145
2	5	8	11	4	0.5723+	0.170	24.600+	1.781
2	5	12	18	7	8.7397+	1.060	6.348+	2.103
2	5	18	20	3	0.9923+	0.026	44.482+	0.214
2	6	1	5	5	1.9009+	0.087	4.921+	0.631
2	6	6	8	3	4.9228+	0.482	6.339+	1.367
2	6	8	11	4	0.5920+	0.168	25.269+	1.760
2	6	12	18	7	8.4624+	1.016	6.061+	2.016
2	6	18	20	3	1.0387+	0.021	42.382+	0.174
2	7	1	5	5	1.8689+	0.119	4.912+	0.861
2	7	6	8	3	4.7416+	0.500	6.584+	1.416
2	7	8	11	4	0.6177+	0.174	24.670+	1.828
2	7	12	18	7	8.9192+	1.017	5.762+	2.018

FLUX ug/m^2/s

SUMMARY OF FLUXES

TSECT	COUP	FROM	TO	PTS	SLOPE	SDEV	INTCPT	SDEV
2	7	18	20	3	1.1335+	0.035	43.713+	0.296
2	8	1	5	5	1.7731+	0.108	5.199+	0.779
2	8	6	8	3	4.5767+	0.467	7.138+	1.324
2	8	8	11	4	0.5970+	0.170	24.478+	1.782
2	8	12	18	7	8.0895+	0.900	5.752+	1.786
2	8	18	20	3	1.0959+	0.016	39.353+	0.131
2	9	1	5	5	1.8739+	0.132	5.142+	0.950
2	9	6	8	3	4.4100+	0.629	7.815+	1.782
2	9	8	11	4	0.5702+	0.163	24.685+	1.703
2	9	12	18	7	7.9841+	0.863	6.059+	1.713
2	9	18	20	3	1.0971+	0.042	38.912+	0.350
2	10	1	5	5	2.1288+	0.110	8.444+	0.792
2	10	6	8	3	4.3897+	0.574	7.714+	1.626
2	10	8	11	4	0.5478+	0.160	24.523+	1.678
2	10	12	18	7	7.9843+	0.802	6.474+	1.590
2	10	18	20	3	1.1127+	0.036	38.925+	0.300
2	11	1	5	5	1.8139+	0.104	3.683+	0.748
2	11	6	8	3	4.0120+	0.608	8.930+	1.724
2	11	8	11	4	0.5260+	0.184	24.322+	1.928
2	11	12	18	7	8.1651+	0.702	6.633+	1.393
2	11	18	20	3	1.0779+	0.037	39.910+	0.309
2	12	1	5	5	1.8718+	0.112	3.097+	0.809
2	12	6	8	3	3.1808+	0.490	5.231+	1.389
2	12	8	10	3	1.0721+	0.137	13.979+	1.060
2	12	12	18	7	9.0037+	0.721	6.362+	1.431
2	12	18	20	3	1.1034+	0.040	43.370+	0.334
2	13	1	4	4	1.5623+	0.187	4.331+	0.983
2	13	6	8	3	5.1270+	1.083	7.559+	3.069
2	13	12	18	7	9.4606+	0.719	6.233+	1.427
2	13	18	20	3	1.0927+	0.026	46.099+	0.214
2	14	1	3	3	1.3317+	0.062	6.965+	0.243
2	14	6	8	3	4.9347+	0.900	7.411+	2.549
2	14	9	11	3	2.0552+	0.842	18.409+	6.821
2	14	12	18	7	9.2398+	0.629	6.100+	1.248
2	14	18	20	3	1.0493+	0.003	44.878+	0.022
2	15	3	5	3	2.5726+	0.044	4.552+	0.252
*** I M S L(UERTST) ***	WARNING				RLMUL		2 (IER =	34)
2	15	6	8	3	3.4658+	0.	9.595+	0.
2	15	8	11	4	0.8453+	0.259	17.366+	2.148
2	15	12	18	7	9.1613+	0.649	6.215+	1.286
2	15	18	20	3	1.0778+	0.011	44.662+	0.088
2	16	2	5	4	2.1650+	0.114	7.654+	0.722
2	16	8	11	4	0.5911+	0.195	18.733+	1.876
2	16	12	18	7	9.1382+	0.691	5.684+	1.370
3	1	1	8	8	2.2159+	0.052	6.598+	0.544
3	1	8	11	4	0.7989+	0.150	30.811+	3.272
3	1	12	18	7	10.0096+	0.830	6.821+	1.647
3	1	18	20	3	0.7650+	0.037	51.118+	0.309
3	2	1	8	8	1.9850+	0.047	6.533+	0.497
3	2	8	11	4	0.7242+	0.138	28.440+	3.019
3	2	12	18	7	8.9384+	0.787	6.016+	1.562
3	2	18	20	3	0.6926+	0.029	45.735+	0.243
3	3	1	8	8	1.6983+	0.040	6.161+	0.424
3	3	8	11	4	0.6344+	0.127	24.331+	2.773
3	3	12	18	7	8.2511+	0.750	6.462+	1.488
3	3	18	20	3	0.7053+	0.028	42.350+	0.235
3	4	1	8	8	1.6543+	0.035	5.711+	0.371
3	4	8	11	4	0.5819+	0.111	23.750+	2.418
3	4	12	18	7	8.3201+	0.765	6.107+	1.517
					FLUX $ug/m^2/s$			

SUMMARY OF FLUXES

TSECT	COUP	FROM	TO	PTS	SLOPE	SDEV	INTCPT	SDEV
3	4	18	20	3	0.8189+	0.031	41.539+	0.259
3	5	1	8	8	1.6612+	0.037	5.317+	0.387
3	5	8	11	4	0.6674+	0.126	22.202+	2.750
3	5	12	18	7	8.3868+	0.723	6.069+	1.435
3	5	18	20	3	0.8398+	0.019	41.421+	0.159
3	6	1	8	8	1.6718+	0.037	5.159+	0.383
3	6	8	11	4	0.6976+	0.130	21.927+	2.845
3	6	12	18	7	8.6380+	0.688	8.023+	1.366
3	6	18	20	3	0.9171+	0.018	44.181+	0.149
3	7	1	8	8	1.5472+	0.038	6.669+	0.396
3	7	8	10	3	0.9143+	0.071	17.538+	1.380
3	7	12	18	7	8.8001+	0.653	5.951+	1.295
3	7	18	20	3	0.9317+	0.022	42.603+	0.183
3	8	1	8	8	1.5138+	0.032	5.235+	0.336
3	8	12	18	7	9.3059+	0.688	6.275+	1.365
3	8	18	20	3	0.9249+	0.019	44.790+	0.156
3	9	1	8	8	1.6063+	0.034	5.750+	0.358
3	9	9	11	3	1.8255+	0.468	15.944+	3.794
3	9	12	18	7	9.1523+	0.663	5.738+	1.315
3	9	18	20	3	0.9985+	0.003	42.960+	0.023
3	10	1	8	7	1.4958+	0.038	5.325+	0.360
3	10	8	11	4	0.9695+	0.194	16.933+	1.609
3	10	12	18	7	9.4544+	0.621	5.221+	1.232
3	10	18	20	3	1.0291+	0.006	43.347+	0.054
3	11	1	6	6	1.4649+	0.023	4.853+	0.194
3	11	8	11	4	0.7779+	0.170	17.213+	1.639
3	11	12	18	7	9.7068+	0.705	5.956+	1.398
3	11	18	20	3	1.0619+	0.009	44.842+	0.079
3	12	1	5	5	1.5340+	0.052	4.285+	0.362
3	12	6	8	3	3.7183+	0.401	3.249+	1.137
3	12	8	11	4	0.7579+	0.144	16.544+	1.511
3	12	12	18	7	9.0664+	0.742	6.233+	1.473
3	12	18	20	3	0.9704+	0.000	42.699+	0.004
3	13	1	4	4	1.4184+	0.011	5.172+	0.056
3	13	5	8	4	2.1727+	0.256	3.662+	1.611
3	13	8	11	4	0.8437+	0.154	15.909+	2.210
3	13	12	18	7	9.5678+	0.697	6.643+	1.383
3	13	18	20	3	0.9548+	0.006	45.849+	0.051
3	14	1	3	3	1.3638+	0.028	5.472+	0.105
3	14	4	8	5	1.9610+	0.136	5.174+	1.074
3	14	8	11	4	0.6871+	0.127	20.128+	2.131
3	14	12	18	7	8.6633+	0.693	6.715+	1.375
3	14	18	20	3	0.7888+	0.009	43.162+	0.073
3	15	3	8	6	1.8294+	0.072	5.230+	0.648
3	15	8	11	4	0.6287+	0.118	21.278+	2.198
3	15	12	18	7	7.7002+	0.684	6.774+	1.358
3	15	18	20	3	0.7825+	0.008	38.584+	0.067
3	16	2	8	7	1.6416+	0.410	4.572+	3.978
3	16	8	11	4	0.5652+	0.110	23.613+	2.238
3	16	12	18	7	7.7982+	0.610	5.950+	1.209
4	1	1	8	8	2.6482+	0.084	8.050+	0.880
4	1	8	11	4	0.9063+	0.231	38.033+	5.053
4	1	12	18	7	11.5027+	0.878	6.917+	1.742
4	1	18	20	3	1.4650+	0.229	54.759+	1.916
4	2	1	8	8	3.0780+	0.096	6.168+	1.008
4	2	8	11	4	0.8631+	0.244	44.524+	5.327
4	2	12	18	7	11.4140+	0.895	6.639+	1.775
4	2	18	20	3	1.3486+	0.194	54.641+	1.622
4	3	1	8	8	2.3257+	0.063	6.133+	0.663

FLUX $ug/m^2/s$

SUMMARY OF FLUXES

TSECT	COUP	FROM	TO	PTS	SLOPE	SDEV	INTCPT	SDEV
4	3	8	11	4	0.7427+	0.192	32.829+	4.202
4	3	12	18	7	9.8739+	0.784	6.859+	1.555
4	3	18	20	3	1.3601+	0.158	46.867+	1.322
4	4	1	8	8	2.4557+	0.065	6.250+	0.686
4	4	8	11	4	0.7885+	0.211	34.430+	4.610
4	4	12	18	7	10.6863+	0.835	7.027+	1.656
4	4	18	20	3	1.4421+	0.163	50.781+	1.364
4	5	1	8	8	2.2398+	0.060	6.131+	0.627
4	5	8	11	4	0.7159+	0.185	32.034+	4.043
4	5	12	18	7	9.8455+	0.807	6.868+	1.602
4	5	18	20	3	1.4147+	0.147	46.779+	1.226
4	6	1	8	8	2.2001+	0.053	5.141+	0.551
4	6	8	11	4	0.7218+	0.189	30.219+	4.123
4	6	12	18	7	9.1511+	0.761	6.644+	1.509
4	6	18	20	3	1.4276+	0.155	42.962+	1.294
4	7	1	8	8	2.1862+	0.052	5.381+	0.547
4	7	8	10	3	1.0490+	0.162	24.203+	3.145
4	7	12	18	7	9.5652+	0.747	7.047+	1.481
4	7	18	20	3	1.3626+	0.137	45.394+	1.143
4	8	1	8	8	2.0956+	0.051	5.905+	0.536
4	8	12	18	7	9.2901+	0.763	6.645+	1.514
4	8	18	20	3	1.3213+	0.125	43.845+	1.045
4	9	1	8	8	2.0512+	0.050	5.926+	0.526
4	9	9	11	3	1.8807+	0.581	18.712+	4.711
4	9	12	18	7	8.8107+	0.743	6.535+	1.474
4	9	18	20	3	1.3387+	0.105	41.573+	0.874
4	10	1	8	7	2.2175+	0.079	6.297+	0.742
4	10	8	11	4	1.1067+	0.304	18.858+	2.525
4	10	12	18	7	9.1517+	0.721	7.184+	1.430
4	10	18	20	3	1.2442+	0.104	44.385+	0.871
4	11	1	6	6	2.3792+	0.028	5.182+	0.231
4	11	8	11	4	0.8319+	0.254	22.694+	2.446
4	11	12	18	7	9.6695+	0.788	7.163+	1.563
4	11	18	20	3	1.2387+	0.100	46.718+	0.835
4	12	1	5	5	2.4269+	0.049	4.571+	0.339
4	12	6	8	3	4.0661+	0.917	5.890+	2.598
4	12	8	11	4	0.7815+	0.237	21.665+	2.479
4	12	12	18	7	9.5967+	0.750	6.433+	1.488
4	12	18	20	3	1.2774+	0.119	45.549+	0.997
4	13	1	4	4	2.4941+	0.058	4.674+	0.292
4	13	5	8	4	2.6261+	0.475	7.694+	2.994
4	13	8	11	4	0.8792+	0.245	24.883+	3.524
4	13	12	18	7	10.1214+	0.836	7.125+	1.659
4	13	18	20	3	1.2238+	0.099	49.257+	0.824
4	14	1	3	3	2.4072+	0.246	5.584+	0.910
4	14	4	8	5	2.8477+	0.216	7.155+	1.704
4	14	8	11	4	0.7626+	0.230	31.575+	3.858
4	14	12	18	7	10.8346+	0.900	6.265+	1.786
4	14	18	20	3	1.1996+	0.090	52.919+	0.755
4	15	3	8	6	3.0084+	0.155	6.689+	1.391
4	15	8	11	4	0.7316+	0.231	37.802+	4.314
4	15	12	18	7	10.9965+	0.932	6.377+	1.848
4	15	18	20	3	1.1660+	0.071	54.250+	0.591
4	16	2	8	7	2.7187+	0.115	7.342+	1.115
4	16	8	11	4	0.7004+	0.199	37.166+	4.035
4	16	12	18	7	10.0171+	0.891	6.367+	1.767

FLUX ug/m^2/s

SUMMARY OF FLUXES

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FOR TEST SECT #1, AVG SLOPE =2.9328+.2109 UG/M2/S,COUP  1- 6 PULLS  1- 5
FOR TEST SECT #2, AVG SLOPE =2.0013+.0934 UG/M2/S,COUP  1- 6 PULLS  1- 5
FOR TEST SECT #3, AVG SLOPE =1.8144+.1976 UG/M2/S,COUP  1- 6 PULLS  1- 7
FOR TEST SECT #4, AVG SLOPE =2.4912+.2792 UG/M2/S,COUP  1- 6 PULLS  1- 7
PULL  5 TEMPS  440- 255C  COUPONS  1- 6
VELOCITY EXPONENT  0.448+/-0.
LOG A= 0.927+/- *.    , A=  2.53E+00
FOR TEST SECT #1, AVG SLOPE =4.7779+.3767 UG/M2/S,COUP  1- 6 PULLS  6- 7
FOR TEST SECT #2, AVG SLOPE =4.5117+.2544 UG/M2/S,COUP  1- 6 PULLS  6- 7
FOR TEST SECT #3, AVG SLOPE =1.8144+.1976 UG/M2/S,COUP  1- 6 PULLS  1- 7
FOR TEST SECT #4, AVG SLOPE =2.4912+.2792 UG/M2/S,COUP  1- 6 PULLS  1- 7
PULL  7 TEMPS  440- 255C  COUPONS  1- 6
VELOCITY EXPONENT  0.612+/-0.
LOG A= 1.292+/- 1.274, A=  3.64E+00
FOR TEST SECT #1, AVG SLOPE =0.8920+.0650 UG/M2/S,COUP  1- 6 PULLS  8-11
FOR TEST SECT #2, AVG SLOPE =0.5554+.0420 UG/M2/S,COUP  1- 6 PULLS  8-11
FOR TEST SECT #3, AVG SLOPE =0.6841+.0634 UG/M2/S,COUP  1- 6 PULLS  8-11
FOR TEST SECT #4, AVG SLOPE =0.7897+.0668 UG/M2/S,COUP  1- 6 PULLS  8-11
PULL 11 TEMPS  440- 340C  COUPONS  1- 6
VELOCITY EXPONENT  0.311+/-0.
LOG A=-0.255+/- 2.293, A=  7.75E-01
FOR TEST SECT #1, AVG SLOPE =*.     +.2940 UG/M2/S,COUP  1- 6 PULLS 12-17
FOR TEST SECT #2, AVG SLOPE =8.4788+.2188 UG/M2/S,COUP  1- 6 PULLS 12-17
FOR TEST SECT #3, AVG SLOPE =8.7574+.5606 UG/M2/S,COUP  1- 6 PULLS 12-17
FOR TEST SECT #4, AVG SLOPE =*.     +.7991 UG/M2/S,COUP  1- 6 PULLS 12-17
PULL 17 TEMPS  490- 325C  COUPONS  1- 6
VELOCITY EXPONENT  0.240+/-0.
LOG A= 2.319+/- 8.729, A=  1.02E+01
FOR TEST SECT #1, AVG SLOPE =1.5321+.0242 UG/M2/S,COUP  1- 6 PULLS 18-20
FOR TEST SECT #2, AVG SLOPE =0.9842+.0831 UG/M2/S,COUP  1- 6 PULLS 18-20
FOR TEST SECT #3, AVG SLOPE =0.7898+.0725 UG/M2/S,COUP  1- 6 PULLS 18-20
FOR TEST SECT #4, AVG SLOPE =1.4097+.0390 UG/M2/S,COUP  1- 6 PULLS 18-20
PULL 20 TEMPS  490- 325C  COUPONS  1- 6
VELOCITY EXPONENT  0.636+/-0.
LOG A= 0.282+/-50.998, A=  1.33E+00
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SUMMARY OF MEAN FLUXES --COUPONS 1-6

RANGE(2)= -1.0
· IF NON-NEGATIVE, PLOT W VS T
IF -.5,PLOT W VS SQRT(T); IF -1, PLOT LOG(W) VS LOG(T)
IF -1.5, PLOT W VS (T & SQRT(T)); IF -2, PLOT W**2 VS T
FOLLOWING HEADINGS APPLY FOR W VS T:
FOLLOWING SLOPE IS UGRAMS/M2/SECOND,

TSECT	COUP	FROM	TO	PTS	SLOPE	SDEV	INTCPT	SDEV
1	1	12	16	5	5.8471+	0.438	1.726+	0.059
1	2	12	16	5	5.5216+	0.382	1.791+	0.052
1	3	12	16	5	5.5202+	0.441	1.823+	0.060
1	4	12	16	5	5.4979+	0.434	1.819+	0.059
1	5	12	16	5	5.6766+	0.519	1.827+	0.070
1	6	12	16	5	5.5360+	0.449	1.772+	0.061
1	7	12	16	5	5.7786+	0.457	1.764+	0.062
1	8	12	16	5	5.5994+	0.463	1.805+	0.063
1	9	12	16	5	5.3634+	0.408	1.794+	0.055
1	10	12	16	5	5.4315+	0.598	1.805+	0.081
1	11	12	16	5	5.7882+	0.651	1.739+	0.088
1	12	12	16	5	6.1264+	0.796	1.712+	0.108
1	13	12	16	5	5.4717+	0.598	1.770+	0.081
1	14	12	16	5	5.6471+	0.678	1.774+	0.092
1	15	12	16	5	5.3474+	0.537	1.809+	0.073
1	16	12	16	5	5.5379+	0.520	1.808+	0.070
2	1	12	16	5	5.5871+	0.626	1.674+	0.085
2	2	12	16	5	5.9711+	0.744	1.628+	0.101
2	3	12	16	5	6.3598+	0.763	1.547+	0.103
2	4	12	16	5	6.3641+	0.718	1.546+	0.097
2	5	12	16	5	5.7744+	0.621	1.678+	0.084
2	6	12	16	5	6.1850+	0.667	1.576+	0.090
2	7	12	16	5	6.6055+	0.761	1.504+	0.103
2	8	12	16	5	6.8697+	0.823	1.416+	0.111
2	9	12	16	5	6.7729+	0.995	1.451+	0.134
2	10	12	16	5	6.4916+	1.079	1.523+	0.146
2	11	12	16	5	5.7551+	0.741	1.640+	0.100
2	12	12	16	5	6.2191+	0.746	1.581+	0.101
2	13	12	16	5	5.5912+	0.796	1.682+	0.108
2	14	12	16	5	5.4225+	0.668	1.675+	0.090
2	15	12	16	5	5.2673+	0.721	1.707+	0.097
2	16	12	16	5	5.7740+	0.803	1.588+	0.109
3	1	12	16	5	5.2627+	0.538	1.812+	0.073
3	2	12	16	5	5.3617+	0.598	1.683+	0.081
3	3	12	16	5	5.6375+	0.744	1.653+	0.101
3	4	12	16	5	6.2843+	0.738	1.528+	0.100
3	5	12	16	5	6.3300+	0.638	1.512+	0.086
3	6	12	16	5	4.8075+	0.372	1.912+	0.050
3	7	12	16	5	6.2221+	0.638	1.524+	0.086
3	8	12	16	5	6.5263+	0.645	1.523+	0.087
3	9	12	16	5	7.0848+	0.713	1.376+	0.096
3	10	12	16	5	7.2813+	0.657	1.289+	0.089
3	11	12	16	5	7.1850+	0.691	1.390+	0.093
3	12	12	16	5	7.0881+	0.644	1.413+	0.087
3	13	12	16	5	6.3667+	0.546	1.582+	0.074
3	14	12	16	5	5.9713+	0.602	1.627+	0.081
3	15	12	16	5	5.9131+	0.595	1.600+	0.080
3	16	12	16	5	5.9596+	0.600	1.515+	0.081
4	1	12	16	5	5.4066+	0.429	1.852+	0.058
4	2	12	16	5	5.7129+	0.475	1.785+	0.064
4	3	12	16	5	5.7821+	0.467	1.727+	0.063
4	4	12	16	5	5.6204+	0.469	1.798+	0.063
4	5	12	16	5	5.6858+	0.528	1.746+	0.071
4	6	12	16	5	5.8910+	0.595	1.666+	0.080
4	7	12	16	5	5.6649+	0.408	1.745+	0.055
4	8	12	16	5	6.1089+	0.524	1.636+	0.071
4	9	12	16	5	5.9571+	0.521	1.631+	0.070
4	10	12	16	5	5.2851+	0.456	1.797+	0.062
4	11	12	16	5	5.7661+	0.487	1.748+	0.066
4	12	12	16	5	5.9847+	0.512	1.649+	0.069
4	13	12	16	5	5.7391+	0.557	1.772+	0.075
4	14	12	16	5	5.2022+	0.503	1.809+	0.068
4	15	12	16	5	4.8706+	0.449	1.873+	0.061
4	16	12	16	5	5.0013+	0.449	1.817+	0.061

FOR TEST SECT #1, AVG SLOPE =5.5999+.1159 UG/M2/S,COUP 1- 6 PULLS 12-16
FOR TEST SECT #2, AVG SLOPE =6.0402+.2696 UG/M2/S,COUP 1- 6 PULLS 12-16
FOR TEST SECT #3, AVG SLOPE =5.6140+.5071 UG/M2/S,COUP 1- 6 PULLS 12-16
FOR TEST SECT #4, AVG SLOPE =5.6831+.1385 UG/M2/S,COUP 1- 6 PULLS 12-16
PULL 16 TEMPS 490- 325C COUPONS 1- 6
VELOCITY EXPONENT -0.019+/-0.
LOG A= 1.741+/- 0.135, A= 5.71E+00

LOG-LOG model of total mass loss vs. time for pulls 12-16. "Slope" is ten times the exponent of time. Exponent approximately equal to 1/2, indicating parabolic mass loss.

```
C      LATEST REVISION APRIL 28, 1980
C      DON BAUER  UW MADISON WISCONSIN 53706
C      CHEM ENGR/ NUCL ENGRG DEPT
C      LITHIUM LOOP EXPERIMENT
C
C
       PROGRAM PROBEGRAF(PROBEDATA,TAPE5=PROBEDATA,OUTPROBE,
      +TAPE6=OUTPROBE,OUTPUT,TAPE9=OUTPUT,PRINT)
       CALL CHANGE(4R+PRB)
       CALL KEEP80(1,3)
       CALL GFSIZE(3,30000008)
90803  CALL FR80ID(7HEXAMPLE,1,2,1)
90804  CALL PLTS
       DIMENSION PURE(3),SCRAT(2,50),ANAME(18),X(50),Y1(50),Y2(50),Y3(50)
       DIMENSION ICOUP(6),IEND(3),AMICR(3)
       IPLOT=0
 19    READ(5,100)I1,I2,IFACTR,WIDE,(IEND(J),AMICR(J),J=1,3)
       IF(I1.GT.3)IPLOT=IPLOT+1
C      WRITE(59,100)I1,I2,IFACTR,WIDE,(IEND(J),AMICR(J),J=1,3)
       IF(I1.LT.0)GO TO 99
       READ(5,105)(ANAME(JNAME),JNAME=1,18)
C      WRITE(59,105)(ANAME(JNAME),JNAME=1,18),IPLOT
       WRITE(6,106)(ANAME(JNAME),JNAME=1,18),IPLOT
       READ(5,107)(ICOUP(IJ),IJ=1,6)
 107   FORMAT(10I1)
 105   FORMAT(18A4," IPLOT ",I2)
 106   FORMAT(17X,18A4," IPLOT ",I2)
       IF(WIDE.LE.0)GO TO 1
       DO 8 IJJ=1,3
 8     AMICR(IJJ)=AMICR(IJJ)*.035/WIDE
 100   FORMAT(3I4,F10.2,3(I4,F8.0))
 1     READ(5,101)((SCRAT(J,I),J=1,2),I=1,I2)
C      WRITE(59,1011)((SCRAT(J,I),J=1,2),I=1,I2)
 101   FORMAT(1X,10F7.0)
 1011  FORMAT(10F7.0)
       IF(IFACTR.EQ.0)IFACTR=1.
       DO 2 IK=1,I2
       DO 2 IJ=1,2
 2     SCRAT(IJ,IK)=SCRAT(IJ,IK)/IFACTR
       GO TO (10,10,10,20,20),I1
 10    SUM=0.
       DO 11 IJ=1,I2
       IF(I1.EQ.1)SUM=SUM+SCRAT(1,IJ)
       IF(I1.EQ.2.OR.I1.EQ.3)SUM=SUM+SCRAT(2,IJ)
 11    CONTINUE
       RI2=I2
       PURE(I1)=SUM/RI2
       WRITE(6,102)I1,PURE(I1),I2
C      WRITE(59,102)I1,PURE(I1),I2
 102   FORMAT(17X,"PURE ELEMENT #",I2," GIVES ",F7.0,
      +"COUNTS; AVERAGE OF ",I2,"READINGS.")
       GO TO 19
 99    CALL DONEPL
       CALL PLOTE
       CALL QUIT(1)
 20    DO 21 JJ=1,I2
       X(JJ)=JJ
       Y1(JJ)=SCRAT(1,JJ)/PURE(1)
       Y2(JJ)=SCRAT(2,JJ)/PURE(I1-2)
       Y3(JJ)=Y2(JJ)/Y1(JJ)
```

```
 21     CONTINUE
        CALL NOBRDR
        CALL TITLE(1H ,1,"POINT $",
       +100,"ATOM FRACTION$",100,6.,8.)
        CALL HEADIN("316 STAINLESS STEEL IN LITHIUM$",100,3,2)
        IF(AMICR(1).GT.0)CALL HEADIN("COMPOSITION PROFILES$",100,3,2)
        IF(AMICR(1).LE.0)CALL HEADIN("BULK COMPOSITION$",100,3,2)
        CALL DFRAME
        INUM=I2/10
        INUMM=INUM*10
        IF(INUMM.NE.I2)INUMM=INUMM+10
        RX=INUMM
        CALL GRAF(0.,5.,RX,0.,.1,1.)
        CALL CURVE(X,Y1,I2,1)
        XP=XPOSN(X(I2),Y2(I2))-.4
        YP=YPOSN(X(I2),Y2(I2))-.35
        IF(I1.EQ.4)CALL MESSAG("CR$",100,XP,YP)
        IF(I1.EQ.5)CALL MESSAG("NI$",100,XP,YP)
        YP=YPOSN(X(I2),Y1(I2))-.35
        CALL MESSAG("FE$",100,XP,YP)
        CALL CURVE(X,Y2,I2,1)
        CALL DOT
        CALL CURVE(X,Y3,I2,0)
        CALL RESET("DOT")
        IF(I1.EQ.4)CALL MESSAG("CR, FE, AND RATIO$",100,.7,6.7)
        IF(I1.EQ.5)CALL MESSAG("NI, FE, AND RATIO$",100,.7,6.7)
        CALL MESSAG("COUPON $",100,.2,7.1)
        DO 1000 KCOUP=1,5
 1000   CALL INTNO(ICOUP(KCOUP),"ABUT","ABUT")
        IF(ICOUP(5).EQ.0)CALL MESSAG("6 MONTHS EXPOSURE$",100,.2,7.8)
        IF(ICOUP(5).EQ.4)CALL MESSAG("4 MONTHS EXPOSURE$",100,.2,7.8)
        IF(ICOUP(3).EQ.2)CALL MESSAG("AS RECEIVED$",100,.2,7.8)
        IF(ICOUP(2).EQ.0)CALL MESSAG("TO 440C LITHIUM$",100,.2,7.6)
        IF(ICOUP(2).EQ.2.AND.ICOUP(3).NE.2)
       +CALL MESSAG("TO 490C LITHIUM$",100,.2,7.6)
        IF(ICOUP(3).EQ.3)CALL MESSAG("0.4M/S VELOCITY LI$",100,.2,7.4)
        IF(ICOUP(3).EQ.4)CALL MESSAG("1 M/S VELOCITY LI$",100,.2,7.4)
        IF(ICOUP(3).EQ.0)CALL MESSAG("1 M/S VELOCITY LI$",100,.2,7.4)
        IF(ICOUP(6).EQ.1)CALL MESSAG("INSIDE WALL$",100,.2,6.9)
        IF(ICOUP(6).EQ.2)CALL MESSAG("OUTSIDE WALL$",100,.2,6.9)
        IF(ICOUP(6).EQ.3)CALL MESSAG("BULK COMPOSITION$",100,.2,6.9)
        CALL INTNO(IPLOT,5.,-.6)
        IF(AMICR(1).EQ.0)GO TO 15
        CALL REALNO(AMICR(1),2,.94,6.5)
        CALL MESSAG(" MICRONS EACH POINT $",100,"ABUT","ABUT")
        IF(IEND(1).EQ.I2)GO TO 15
        CALL MESSAG(" 1 TO $",100,"ABUT","ABUT")
        CALL INTNO(IEND(1),"ABUT","ABUT")
        CALL REALNO(AMICR(2),2,.82,6.3)
        CALL MESSAG(" MICRONS EACH POINT $",100,"ABUT","ABUT")
        CALL INTNO(IEND(1),"ABUT","ABUT")
        CALL MESSAG(" TO $",100,"ABUT","ABUT")
        CALL INTNO(IEND(2),"ABUT","ABUT")
        X(1)=IEND(1)
        X(2)=IEND(1)
        Y1(1)=1.
        Y1(2)=0.
        CALL DASH
        CALL CURVE(X,Y1,2,0)
        IF(IEND(2).EQ.I2)GO TO 15
```

```
      CALL REALNO(AMICR(3),2,.7,6.1)
      CALL MESSAG(" MICRONS EACH POINT $",100,"ABUT","ABUT")
      CALL INTNO(IEND(2),"ABUT","ABUT")
      CALL MESSAG(" TO $",100,"ABUT","ABUT")
      CALL INTNO(IEND(3),"ABUT","ABUT")
      X(1)=IEND(2)
      X(2)=IEND(2)
      CALL CURVE(X,Y1,2,0)
15    CALL RESET("DASH")
      CALL ENDPL(0)
      GO TO 19
      END
```

APPENDIX U. PROGRAM METAL

Stepwise Integration Solution of
Differential Equation for Mass Transfer
Around Lithium Loop

(Uses IMSL routine DREBS; also graphics
routines from DISSPLA.)

```
C        LATEST REVISION FEBRUARY 20,1980
        PROGRAM METAL (METDAT,TAPE5=METDAT,OUTMET,TAPE6=OUTMET,PRINT,
       +INSAV,TAPE7=INSAV,OUTSAV,TAPE8=OUTSAV,OUTPUT,TAPE9=OUTPUT)
C       WRITTEN BY DON BAUER JULY 1979 TO OPTIMIZE PARAMETERS
C       IN MASS TRANSFER EQUATION FOR A NON-ISOTHERMAL FLOW LOOP
C       BY NON-LINEAR LEAST SQUARES
C       WITH TRIAL STEPS ON THE INDIVIDUAL PARAMETERS TO
C       ITERATE DOWN THE SUM-OF-SQUARES SURFACE TOWARD A VALLEY
C       UW MADISON WISCONSIN 53706
C.001       .0002      .0000003  100. 300.        00.0202-10001000101251O233502
        CALL CHANGE(4R+MET)
C
C
        CALL KEEP80(1,3)
        CALL FR80ID("EXAMPLE",1,3)
        CALL PLTS
        INTEGER DOPT,TOPT
        DIMENSION AREAD(20),A(20,5),A0(20,5)
        COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
       +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
       +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
       +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
       +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
       +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
       +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
       +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
       +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
       +,ZEXTRA(5),ABCD
        DIMENSION PDX0(20),PDX(20),SQPAR(2,20),PMOVE(20),Y(5),S(5)
        DIMENSION DEVPAR(2,20)
        DATA A0/623.,100.,2255.,1.6,2957.,1.,47.5,-18.,14500.,0.,100.,
       +3*0.,-18.,-15.,-18.,3*14500.,
       + 697.,86.,2255.,1.6,2957.,1.,47.5,-18.,14500.,0.,100.,
       +3*0.,-18.,-15.,-18.,3*14500.,
       +669.5,53.5,2255.,1.6,2957.,1.,47.5,-18.,14500.,0.,100.,
       +3*0.,-18.,-15.,-18.,3*14500.,
       +723.,88.5.,0.,2.2,1500.,1.,58.,-18.,14500.,0.,50.,
       +3*0.,-18.,-15.,-18.,3*14500.,
       +773.,100.,0.,2.2,232.,1.,4.23,-18.,14500.,1.27,8.,
       +3*0.,-18.,-15.,-18.,3*14500./
        DATA ZSTEP/100./,ZETSTP/5./,UPSTRM/5*0./,ZEXTRA/5*0./
       +,RECRIT/350000./
C
C
C       SET FLOW SPLIT POINTS
        DATA XSPLIT /200.,300.,400.,2957.,0.,200.,300.,400.,2957.,0.,
       +200.,300.,400.,2957.,0.,250.,300.,500.,550.,1500.,5*100./
C       SET 1ST, LAST PARAMETER NUMBER; SET PARAMETER TEST STEP SIZES
        DATA NNP1ST/15/,NNP2ND/15/,PDX0/7*0.,1.E-2,2.,5*0.,
       +.01,2.,.01,2.,.01,2./
C       SET EXPERIMENTAL FLUXES
        DATA FLXEXP/.2933,0.,.2001,0.,.1814,0.,.2491,0.,0.,0.,
       +1.0480,0.,.7943,0.,.8205,0.,.9842,0.,0.,0.,
       +.0892,0.,.0555,0.,.0684,0.,.0790,0.,0.,0.,
       +8*0.,.8,0.,8*0.,.314,0./
        DATA FSPLIT/.398,.19,.131,.281,1.,.398,.19,.131,
       +.281,1.,.398,.19,.131,.281,1.,10*1./,XTEST/30*350.,
       +10*275.,10*104./
C   *****CHECK --IS MOLAR DENSITY OF CR,NI,FE ROUGHLY DENSM=1/7?
        DATA AMW/55.84,52.,58.71/,PHI/.7,.18,.12/,DENSM/.14/
```

```
          PHISUM=1.+(PHI(2)/AMW(2)+PHI(3)/AMW(3))/(PHI(1)/AMW(1))
    C
    C     PREPARE GRAPH LEGENDS
          CALL LINES("T,200-700C $",IPAK1,1)
          CALL LINES("SCHM,0-200 $",IPAK1,2)
          CALL LINES("DIAM,0-.1M $",IPAK1,3)
             CALL LINES("L/D,0-1000 $",IPAK1,4)
          CALL LINES("VEL,0-2M/S $",IPAK1,5)
          CALL LINES("REYN,0-10K $",IPAK1,6)
          CALL LINES("SOL,X E10 $",IPAK2,1)
          CALL LINES(" C ,X E10 $",IPAK2,2)
          CALL LINES(" N ,+-X E12 $",IPAK2,3)
    C
    C
    C     CHANGE THE FLUXES FROM G/M2/(10+5S) TO MOLE/CM2 PER SECOND
          DO 2 I6=1,2
          DO 2 J6=1,5
          DO 2 LNUM=1,5
     2    FLXEXP(I6,J6,LNUM)=-FLXEXP(I6,J6,LNUM)*1.E-9/AMW(1)
    4     NP1ST=NNP1ST
          NP2ND=NNP2ND
          DO 6 I6=1,20
          PDX(I6)=PDXO(I6)
          DO 6 J6=1,5
    6     A(I6,J6)=AO(I6,J6)
    C     ****************************************************************
    C     *****************************************************************
    .001      .0002     .0000003  025. 100.        00.0202-100010004042510233502
    -18.       18000.

    C     READ THESE VARIABLES AND PARAMETERS:
    C     YI=INIT CONC;  ANC=TRIAL STEP  EPSLIM=MASS BLNCE ACCRCY
    C     DTIME=TIME STEP ;DPAR=FLAG: LE ZERO READ PARAM. TRIAL STEPS
    C       ETIME=END TIME                DPAR EQ ZERO READ PARAMETER
    C     TOPT=TEMP FLAG: 1=SINE,2=TABLE; DOPT=DIAM FLAG: 1=CONST.,2=TABLE
    C     LAMTUR=FLAG: POS.=CONSTANT L/D, NEG.=L/D CALC. EACH POINT
    C     LAMTUR, ALSO:-2IMPLIES 1/2 POWER DEVELOPING FLAT PLATE FLOW
    C     LAMTUR, ALSO: -3 IMPLIES 1/3 POWER DEVELOPED CHANNEL FLOW
    C     NIKIRN=FLAG; 0=IRON.
    C     LNUM=LOOP NUMBER; NOW #1:450/250,#2:450/350,#3:500/300,#4:ARD,#5:ORNL
    C     IWT=WRITE FLAG
    C     N1=FIRST LOOP CONSIDERED    N2=LAST LOOP CONSIDERED
    C     IEXP=NEGATIVE POWER OF TEN CONVERGENCE
    C     ITLIM NUMBER OF ITERATIONS ALLOWED ON PARAMETERS
    C     ICUTL  CUTOFF (HIGH END OF LAMINAR RANGE)
    C     ICUTH  CUTOFF (LOW END OF TURBULENT RANGE REYNOLDS NUMBER)
    C     IHAUSN 0=SIEDER TATE  1=HAUSEN 2=MODIFIED S-T TRANSITION RANGE
    C
    C
    C     ****************************************
    C     ****************************************
          READ(5,10)YI(1,1),AINC(1,1),EPSLIM,DTIME,ETIME,DPAR,TOPT,DOPT,
         +LAMTUR,NIKIRN,LNUM,IWT,N1,N2,IEXP,ITLIM,ICUTL,ICUTH,IHAUSN,IFLXX
          IF(YI(1,1).NE.0.)WRITE(6, 5)
     5  FORMAT("1")
          WRITE(6,10)YI(1,1),AINC(1,1),EPSLIM,DTIME,ETIME,DPAR,TOPT,DOPT,
         +LAMTUR,NIKIRN,LNUM,IWT,N1,N2,IEXP,ITLIM,ICUTL,ICUTH,IHAUSN,IFLXX
          IF(YI(1,1).EQ.0.)CALL DONEPL
          IF(YI(1,1).EQ.0.)CALL QUIT(1)
          YI(1,1)=YI(1,1)*1.E-6
```

```
      DO 5000 IYI=1,5
      DO 5000 JYI=1,5
5000  YI(IYI,JYI)=YI(1,1)
C
C     CALCULATE LOGARITHMIC CONSTANTS TO BE USED LATER
      CUTL=100.*ICUTL
      CUTH=100.*ICUTH
      CUTLL=ALOG(CUTL)
      CUTHL=ALOG(CUTH)
C*****************NOTE  USE OF 1.62, LEVEQUE, RATHER THAN S-T 1.86
C     *****************NOTE TURBULENT RANGE USE OF .026 COEFFICIENT*
      ALN196=ALOG(1.62)
      ALN26=ALOG(.026)
      REHALF=3300.
      IF(IHAUSN.EQ.2)REHALF=CUTL
      IF(IHAUSN.EQ.2)RECRIT=CUTH*100.
      BPOWER=ALOG(REHALF)-ALOG(2100.)
      REALK=EXP(ALOG(2100.)/BPOWER)
      IF(DPAR.EQ.1)READ(7,5001)((A(IA,JA),IA=1,20),JA=1,5),(PDX(IA),
     +IA=1,20),((YI(IA,JA),IA=1,5),JA=1,5),((AINC(IA,JA),IA=1,5),
     +JA=1,5),(UPSTRM(JA),JA=1,5),(ZEXTRA(JA),JA=1,5)
      IF(DPAR.EQ.1)GO TO 101
5001  FORMAT(5E20.6)
      IF(DPAR.LE.0.)READ(5, 8)(AREAD(IP),IP=NP1ST,NP2ND)
      IF(DPAR.LT.0.)READ(5, 8)(PDX(IP),IP=NP1ST,NP2ND)
      IF(DPAR.LT.0)READ(5,7)NP1ST,NP2ND
7     FORMAT(2I2)
 8    FORMAT(8F10.3)
C
C
C     MAKE SURE ALL TEST CASES USE THE SAME PARAMETER VALUES
      DO  9 IL=1,5
      DO  9 IP=NP1ST,NP2ND
      IF(AREAD(IP).EQ.0..AND.DPAR.EQ.0.)PDX(IP)=0.
 9    IF(AREAD(IP).NE.0)A(IP,IL)=AREAD(IP)
10    FORMAT(3F10.0,2F5.0,F10.0,20I2)
C     AINC IS THE INITIAL STEP ITERATION ON THE CONCENTRATION
      AINC(1,1)=AINC(1,1)*1.E-6
      DO 11 IAINC=1,5
      DO 11 JAINC=1,5
11    AINC(IAINC,JAINC)=AINC(1,1)
101   ITERC=0
      ITER=0
      NNLAST=0
      SQAR1=0.
      SQARL=10.**-IEXP
C     EPSLIM IS THE ACCURACY REQUIRED OF THE MASS BALANCE
      EPSLIM=1.E-6*EPSLIM
C
C
C     TELL USER IF DATA ARE WEIGHTED, AND WHICH PARAMS. VARIED
      WRITE(6, 12)YI(1,1),AINC(1,1),EPSLIM,TOPT,DOPT,LAMTUR,N1,N2,
     +CUTL,CUTH,IHAUSN
 12    FORMAT("  INIT GUESS CONCEN=",E10.2,
     +", TRIAL STEP=",E10.2,/,"  CONVERGE MASS BALANCE TO",
     +E10.2,/," TEMP OPTION #",I2,", DIAM OPTION #",I2,",
     + L/D=",I2,/," LOOPS #",I2," TO #",I2," ARE TESTED.",/,
     +"  REYNOLDS LOW BREAK=",F5.0,", HIGH=",F5.0,
     +", HAUSEN(1)/S-T(0)=",I2)
      WRITE(6, 14)
```

```
 14   FORMAT(" FOR LOOPS TESTED THESE ARE BASIC PARAMETERS:",/,
     +" TMID    TDEL/2  ZRO CRS NOM.DIA LENGTH WGHT.FCT FLOW...
     +AEXP    ACTENG COUP.WID TABLE DX",/)
      WRITE(6, 16)((A(IP,IL),IP=1,11),IL=N1,N2)
 16   FORMAT(11F8.2)
      IF(IWT.NE.0)WRITE(6, 70)
      IF(IWT.EQ.0)WRITE(6, 72)
      WRITE(6, 26)NP1ST,NP2ND
      IF(DPAR.GE.0.)GO TO  28
      A(NP1ST,1)=A(NP1ST,1)-5.*PDX(NP1ST)
      A(NP2ND,1)=A(NP2ND,1)-5.*PDX(NP2ND)
      DO  18 LNUM=2,5
      A(NP1ST,LNUM)=A(NP1ST,1)
 18   A(NP2ND,LNUM)=A(NP2ND,1)
      DO  24 IP1=1,10
      A(NP1ST,1)=A(NP1ST,1)+PDX(NP1ST)
      DO  22 IP2=1,10
      A(NP2ND,1)=A(NP2ND,1)+PDX(NP2ND)
      DO  20 LNUM=N1,N2
      A(NP1ST,LNUM)=A(NP1ST,1)
      A(NP2ND,LNUM)=A(NP2ND,1)
 20   CALL CRUNCH
      CALL SQUAR(SSL,DEVL,PCENT)
      WRITE (6,30)ITER,A(NP1ST,N1),A(NP2ND,N1),SSL
 22   CONTINUE
C     CRUNCH IS PROGRAM TO CLOSE MASS BALANCE I.E. SOLVE DIFFY EQN
C
C
C
      A(NP2ND,1)=A(NP2ND,1)-10.*PDX(NP2ND)
 24   CONTINUE
      GO TO 4
 26   FORMAT("   ITERATION, AND PARAMETER ",I2,"-",I2," ESTIMATES
     + & SUM SQRS OF DEVS",/,"     FIRST ROW IS SIZE OF PARAMETER
     + TEST STEPS, AND DESIRED SSQ CONVERGENCE.")
 28   XIEXP=10.**-IEXP
      ITIME=0
C
C
      WRITE(6, 30)IZ,(PDX(IPDX),IPDX=NP1ST,NP2ND),XIEXP
 29   ITERC=ITERC+1
 30   FORMAT(1X,I3,5E15.4)
C     QUIT IF THE ITERATIONS ARE GOING ON FOR TOO LONG
      IF(ITERC.GT.ITLIM)NNLAST=1
 32   ABCD=PCENT
      DO  35 LNUM=N1,N2
C     SOLVE EQUATION FOR EACH CASE AND THEN SUM SQUARES
 35   CALL CRUNCH
      CALL SQUAR(SQAR1,DEV1,PCENT)
      IF(NNLAST.EQ.1)GO TO  54
      IF(ABS(SQAR1-SQARL).LE.XIEXP.OR.ABS(SQAR1).LE.XIEXP)NNLAST=1
      SQARL=SQAR1
      IF(NNLAST.EQ.1)GO TO  32
5002  WRITE(6, 30)ITERC,(A(ICC,N1),ICC=NP1ST,NP2ND),SQAR1
C
C
C     FROM HERE TO 15, MAKE 2 MOVES EACH PARAM. SEPARATELY, IN TURN,
C     TO APPROX. SLOPE ,SECOND DERIVATIVE OF SUM SQR VS PARAMETER
      DO  48 IPAR=NP1ST,NP2ND
      IF(PDX(IPAR).EQ.0.)GO TO 48
```

```
      DO  44 IPARDX=1,2
      DO  40 LNUM=N1,N2
   40   A(IPAR,LNUM)=A(IPAR,LNUM)+PDX(IPAR)
  401 DO  42 LNUM=N1,N2
   42  CALL CRUNCH
      CALL SQUAR(SQPAR(IPARDX,IPAR),DEVPAR(IPARDX,IPAR),PCENT)
   44  CONTINUE
C     RESET PARAMETER TO BASE POINT VALUE
      DO  46 LNUM=N1,N2
   46  A(IPAR,LNUM)=A(IPAR,LNUM)-2.*PDX(IPAR)
   48  CONTINUE
C
C
C     FOR PARAMETERS FOR WHICH OPTIMIZATION STILL EFFECTIVE
C     DECIDE PMOVE TO MOVE TOWARD VALLEY OF SUM SQUARES
      DO  50 IPAR=NP1ST,NP2ND
      IF(PDX(IPAR).EQ.0.)GO TO  50
      DIVISR=SQPAR(1,IPAR)-SQPAR(2,IPAR)
      IF(DIVISR.EQ.0)PMOVE(IPAR)=1.5*PDX(IPAR)
      IF(DIVISR.EQ.0)GO TO  50
      RATIO=(SQAR1-SQPAR(1,IPAR))/(SQPAR(1,IPAR)-SQPAR(2,IPAR))
      IF(RATIO.LE.0.)PMOVE(IPAR)=.5*PDX(IPAR)
      IF(RATIO.EQ.1.0)GO TO  50
      IF(ABS(SQAR1-SQPAR(1,IPAR)).LE.10.**-(IEXP+1))PMOVE(IPAR)=0.
      IF(ABS(SQAR1-SQPAR(1,IPAR)).LE.10.**-(IEXP+1))GO TO  50
      PMOV1=PMOVE(IPAR)
      PMOVE(IPAR)=(SQAR1-SQPAR(1,IPAR))*PDX(IPAR)/
     +((SQPAR(2,IPAR)-SQPAR(1,IPAR))-(SQPAR(1,IPAR)-SQAR1))
      IF((PMOV1/PMOVE(IPAR)).LT.0)PDX(IPAR)=.5*PDX(IPAR)
   50  CONTINUE
C
C
C     IF NONE OF THE PARAMETERS NEEDS CHANGE THEN QUIT
C     FOR EACH PARAM, FOR EACH CASELOOP, ADJUST PARAMETERS
      SUMPMV=0.
      DO  52 IPAR=NP1ST,NP2ND
      SUMPMV=SUMPMV+PMOVE(IPAR)
      DO  52 LNUM=N1,N2
   52  A(IPAR,LNUM)=A(IPAR,LNUM)+PMOVE(IPAR)
      IF(SUMPMV.EQ.0)NNLAST=1
      GO TO  29
   54  WRITE(6, 56)ITERC,ITER,(A(IPAR,N1),IPAR=NP1ST,NP2ND),SQAR1
      NNLAST=0
   56  FORMAT(" PARAMETER ESTIMATES AND SUM SQRS DEVS, ITERATION #",
     +I4,"(",I4,")",/,2(5E15.5,/))
   58  FORMAT(/," LAMTUR=",I2,"(-2 IS .5, -3 IS .333 POWER OF VEL/X)"
     +,/,"LOOP/RUN #",I2,"  HOT ZONE EXP; THEORY FLUXES.",/
     +" AVERAGE DEVIATION OF THEORY FROM EXPERIMENT =",F4.0,"%.")
   60  FORMAT(/,"LOOP/RUN #",I2," COLD ZONE EXP; THEORY FLUXES",/)
  601  IF(DTIME.NE.0)ITIME=ITIME+1
       WRITE(8,5001)((A(IA,JA),IA=1,20),JA=1,5),(PDX(IA),
     +IA=1,20),((YI(IA,JA),IA=1,5),JA=1,5),((AINC(IA,JA),IA=1,5),JA=1,5)
     +,(UPSTRM(JA),JA=1,5),(ZEXTRA(JA),JA=1,5)

       DO  64 LNUM=N1,N2
C
C
C      WRITE ZONE ONE FLUX DATA
       WRITE(6, 58)LAMTUR,LNUM,PCENT
       WRITE(6,62)(FLXEXP(1,IS,LNUM),IS=1,5),(FLXTHY(1,IS,LNUM),IS=1,5)
```

```
 62    FORMAT(5E12.2)
C     WRITE ZONE 2 FLUX DATA IF ANY
      IF(FLXEXP(2,1,LNUM).NE.0.)WRITE (6, 60)LNUM
      IF(FLXEXP(2,1,LNUM).NE.0)WRITE(6,62)
     +(FLXEXP(2,IS,LNUM),IS=1,5),(FLXTHY(2,IS,LNUM),IS=1,5)
 64    CONTINUE
      IF(ITIME.NE.1)GO TO 65
      DO 645 LNUM=N1,N2
645 CALL CRUNCH
65    WRITE(6, 68)LAMTUR
      WRITE(6,10)YI(1,1),AINC(1,1),EPSLIM,X,DPAR,TOPT,DOPT,LAMTUR,
     +NIKIRN,LNUM,IWT,N1,N2,IEXP,ITLIM,ICUTL,ICUTH,IHAUSN,IFLXX
      WRITE(6, 66)
 66   FORMAT(50X,"T D LTFELNIWN1N2ACITRLRHNU")
 68    FORMAT("    **********************************************************
     +FLUXES ARE IN MOLES/SEC/CM2",/,
     +"     FOR LAMINAR, L/D=",I2,",(NEGATIVE IS AUTO).",/////)
 70    FORMAT("   LITHIUM LOOPSYSTEMS PARAMETER OPTIMIZATION.",/,
     +"  ***DEVIATIONS WEIGHTED BY EXP(773./T-1.)/VELOCITY.")
 72   FORMAT("   LITHIUM LOOPSYSTEMS PARAMETER OPTIMIZATION.",/,
     +"  ***DEVIATIONS NOT WEIGHTED BY VELOCITY OR TEMPERATURE.")
      GO TO 4
      END
C
C
C
C
C     ***************************************************************
C     ***************************************************************
      SUBROUTINE SQUAR(SQAR,SIGNDV,PCENT)
      DIMENSION A(20,5)
      COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
     +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
     +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
     +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
     +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
     +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
     +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
     +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
     +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
     +,ZEXTRA(5),ABCD
      SQAR=0.
      SIGNDV=0.
      DIV=0.
      PCENT=0.
C     SUM THE SQUARES OF DEVIATIONS BETWEEN EXP AND THEORY FLUXES
C     ALSO SUM THE SIGNED SQUARE OF DEVIATIONS
C     ALSO ADD UP PERCENT DEVIATIONS
      DO 10 I=N1,N2
      DO 10 J=1,5
      WEGHT=1.
C     WEIGHT THE INDIVIDUAL LOOP DATA?
      WGHTL=A(6,I)
C     WEIGHT THE DATA BY TEMP/VELOCITY?
      IF(IWT.NE.0)WEGHT=WGHTL*EXP(773./(A(1,I)+A(2,I))-1.)/
     +FSPLIT(J,I)
C     COUNT DATA OF ZONE 1 OR 2 OR BOTH, IF PRESENT
      DO 10 K=1,2
      IF(FLXEXP(K,J,I).EQ.0.)GO TO 10
      SQAR=SQAR+((FLXEXP(K,J,I)-FLXTHY(K,J,I))*WEGHT)**2
```

```
      SIGN=1.
      IF(FLXEXP(K,J,I).GT.FLXTHY(K,J,I))SIGN=-1.
      SIGNDV=SIGNDV+SIGN*((FLXEXP(K,J,I)-FLXTHY(K,J,I))
     +*WEGHT)**2
      PCENT=PCENT+ABS((FLXEXP(K,J,I)-FLXTHY(K,J,I))/
     +FLXEXP(K,J,I))
      DIV=DIV+1
10    CONTINUE
      PCENT=PCENT/DIV*100.
      RETURN
      END
C
C
C     ***************************************************************
C     ***************************************************************
      SUBROUTINE CRUNCH
C     THIS SUBROUTINE SOLVES THE MASS BALANCE AROUND LOOP
      INTEGER DOPT,TOPT
      DIMENSION A(20,5),WK(145),R(5),YMIX(5,5),DELMIC(5,600)
      DIMENSION DELMTS(5,40,5),XDRAW(35),YDRAW(35,20),IVELS(100)
      DIMENSION YDR1(35),YDR2(35),YDR3(35),YDR4(35),YDR5(35),
     +YDR6(35),YDR7(35),YDR8(35),YDR9(35),YDR10(35),
     +YDR11(35),YDR12(35),YDR13(35),YDR14(35),YDR15(35),YDR16(35)
      EQUIVALENCE (YDR1,YDRAW(1,1))
      EQUIVALENCE (YDR2,YDRAW(1,2))
      EQUIVALENCE (YDR3,YDRAW(1,3))
      EQUIVALENCE (YDR4,YDRAW(1,4))
      EQUIVALENCE (YDR5,YDRAW(1,5))
      EQUIVALENCE (YDR6,YDRAW(1,6))
      EQUIVALENCE (YDR7,YDRAW(1,7))
      EQUIVALENCE (YDR8,YDRAW(1,8))
      EQUIVALENCE (YDR9,YDRAW(1,9))
      EQUIVALENCE (YDR10,YDRAW(1,10))
      EQUIVALENCE (YDR11,YDRAW(1,11))
      EQUIVALENCE (YDR12,YDRAW(1,12))
      EQUIVALENCE (YDR13,YDRAW(1,13))
      EQUIVALENCE (YDR14,YDRAW(1,14))
      EQUIVALENCE (YDR15,YDRAW(1,15))
      EQUIVALENCE (YDR16,YDRAW(1,16))
      COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
     +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
     +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
     +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
     +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
     +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
     +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
     +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
     +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
     +,ZEXTRA(5),ABCD
      DIMENSION YMOVE(3), YO(3), FLXNAM(10), Y(5),S(5)
      DIMENSION YSAVE(5),YD(3),YLAST(3),DEL(3),DEL1(3)
      EXTERNAL FCN
      DATA N/3/,HMIN/1./,VM/7./,TOL/.005/,JM/6/,IND/1/
      DATA FLXNAM/"GMMS","GMKH","U/YR","M/YR",6*"----"/
      DATA FLXMUL/1.E+10,3.6E+10,3.154E+11,1.242E+10,6*1./
      DX=A(11,LNUM)/2.
      TIME=0.
      NMETAL=1
      IF(ITIME.NE.0)NMETAL=3
C     SET IN FIRST FLOW SPLIT, SECTION 5 (MAIN FLOW,UNDIVIDED)
```

```
      ISPLIT=1
      ISECT=5
      HO=DX
      H=HO
      ITLAST=0
C     INITIALIZE CONCENTRATION OF METAL.
      DO 14 I14=1,3
      Y(I14)=YI(I14,LNUM)
      YO(I14)=Y(I14)
      DO 14 J14=1,600
14    DELTA(I14,J14)=0.
C
C
15    X=0.
      JSTART=0
      DO 18 IVAR=1,N
18    S(IVAR)=Y(IVAR)
C     CALL THE DIFFERENTIAL EQUATION SOLVER
19    CALL DREBS(FCN,Y,X,N,JM,IND,JSTART,H,HMIN,TOL,R,S,WK,IER)
      IF(IER.NE.0)CALL QUIT(1)
C     HOW FAR FROM END OF LOOP?
      TEMP=A(5,LNUM)-X
C     IS X AT THE END OF LOOP YET?
      IF(TEMP.LT.HMIN)GO TO 20
      IF(H.GT.HO)H=HO
      H=AMIN1(H,TEMP)
      GO TO 19
20    CONTINUE
C     HOW FOR OFF(DEL) IS THE MASS BALANCE
      DO 22 METAL=1,NMETAL
      DEL(METAL)=Y(METAL)-YO(METAL)
C     SAVE THIS "LAST"VALUE OF YO(METAL), MAKE NEW ONE
      YLAST(METAL)=YO(METAL)
C     YO(METAL)=YO(METAL)+AINC(METAL,LNUM)
C     Y(METAL)=YO(METAL)
      YO(METAL)=Y(METAL)
C
C
 22   X=0
      CALL SOLBIL(200.)
      SCALE=SOL(1)*1.E10
      ISC1=SCALE/10
      SCALE=ISC1*10.
      IF(ISC1.EQ.0)SCALE=10.
      SC10=ISC1
      IXDRAW=0
      ISPLIT=1
      ISECT=5
      ITER=ITER+1
27    DO  25 IS=1,5
      JSTART=0
 25   S(IS)=Y(IS)
 26    CALL DREBS(FCN,Y,X,N,JM,IND,JSTART,H,HMIN,TOL,R,S,WK,IER)
      IF(IER.NE.0)CALL QUIT(1)
 28   FORMAT(1X,2F5.0,2E9.2,F6.2,F5.0,F5.2,F5.2,
     +2F5.0,F7.0,5E9.2,F6.2)
      IF(ITIME.NE.0)SUMFLX=FLUX(1)*AMW(1)+FLUX(2)*AMW(2)+
     +FLUX(3)*AMW(3)
      IF(ITIME.EQ.0)SUMFLX=FLUX(1)*PHISUM*AMW(1)
      FLUXX=SUMFLX*3600.*30.*24.*1000.
```

```
      FLUXXX=SUMFLX*FLXMUL(IFLXX)
      IWD=X/A(11,LNUM)
      IWD=IWD*2+1
      IWDD=0
      XIWD=X-IWD*A(11,LNUM)/2.
      IWW=X/DX
      IF(IWW*DX.EQ.X)IWW=1
C     IF(IW.EQ.2.AND.((X.GE.200..AND.X.LE.400.).OR.IWW.EQ.1))WRITE
      IF(IW.EQ.2)WRITE
     +(6, 28)X,TC,Y(1),SOL(1),FLUXX,VEL,DIAM,DIAA,RLAM,SCHM,REYN,
     +RNUSS,DIFF,RKMASS,DELC(1),TERM,FLUXXX
      IF(IW.NE.2.OR.ABS(XIWD).GE.(1.E-1).OR. ISECT.LT.4)GO TO  29
C
C     SET UP GRAPH ARRAYS
      IXDRAW=IXDRAW+1
      XDRAW(IXDRAW)=X/100.
      YDR1(IXDRAW)=(TC-200.)/50.
      YDR2(IXDRAW)=Y(1)*1.E+10
      YDR3(IXDRAW)=SOL(1)*1.E+10
      YDR4(IXDRAW)=FLUX(1)*1.E+12+5.*ISC1
      YDR5(IXDRAW)=VEL/20.
      YDR6(IXDRAW)=DIAM
      YDR7(IXDRAW)=DIAA
      YDR8(IXDRAW)=RLAM/100.
      YDR9(IXDRAW)=SCHM/20.
      YDR10(IXDRAW)=REYN/1000.
      YDR11(IXDRAW)=RNUSS
      YDR12(IXDRAW)=DIFF
      YDR13(IXDRAW)=RKMASS
      YDR14(IXDRAW)=DELC(1)
      YDR15(IXDRAW)=TERM
      YDR16(IXDRAW)=FLUXXX
C
C
  29  TEMP=XSPLIT(ISPLIT,LNUM)-X
      IF(H.GT.HO)H=HO
      H=AMIN1(H,TEMP)
C     SAVE THE THEORY VALUE OF FLUX IN ZONE ONE SECTION ISECT
C     START REGULAR SOLUTION
      IF(X.GT.XTEST(1,ISECT,LNUM)-1..AND.X.LT.XTEST(1,ISECT,
     +LNUM)+1.)FLXTHY(1,ISECT,LNUM)=FLUX(1)*PHISUM
C     SAVE THE THEORY VALUE FOR FLUX IN ZONE TWO SECTION ISECT
      IF(X.GT.XTEST(2,ISECT,LNUM)-1..AND.X.LT.XTEST(2,ISECT,
     +LNUM)+1.)FLXTHY(2,ISECT,LNUM)=FLUX(1)*PHISUM
C     LOOP SPLIT POINT OR END? CHECK INDIVID. LOOP INSTRUCTIONS
      IF(TEMP.LT.HMIN)GO TO ( 50, 50, 50,56,56),LNUM
      GO TO  26
  30  H=HO
C     DEL1 IS MASS IMBALANCE, YMOVE IS SECANT ITERATION MOVE
C     YD IS NEW BEST INITIAL GUESS ON CONCENTRATION
C     SAVE YLAST ANDTHIS DEL FOR NEXT ITERATION, RESET YO AND Y(1)
      DO 341 METAL=1,NMETAL
      DEL1(METAL)=Y(METAL)-YO(METAL)
      ABD=ABS(DEL1(METAL))
      IF(ABD.LE.EPSLIM)GO TO 341
      IF(DEL(METAL).EQ.DEL1(METAL))GO TO 34
      YMOVE(METAL)=DEL1(METAL)*((YLAST(METAL)-YO(METAL))/
     +(DEL(METAL)-DEL1(METAL)))
  34  YD(METAL)=YO(METAL)-YMOVE(METAL)
      AINC(METAL,LNUM)=.2*YMOVE(METAL)
```

```
      YLAST(METAL)=YO(METAL)
      DEL(METAL)=DEL1(METAL)
      Y(METAL)=YD(METAL)
      YO(METAL)=Y(METAL)
341   CONTINUE
C      IS THE MASS BALANCE GOOD ENOUGH (WITHIN EPSLIM)
      ABD=ABS(DEL1(1))
C*****WRITE(6,5959)ABD
5959  FORMAT(E20.4)
      IF(ABD.GT.EPSLIM)GO TO 22
      IF(NMETAL.EQ.1)GO TO 342
      ABD=ABS(DEL1(2))
      IF(ABD.GT.EPSLIM)GO TO 22
      ABD=ABS(DEL1(3))
      IF(ABD.GT.EPSLIM)GO TO 22
342   IF(ITIME.NE.1)GO TO 393
C
C     ADJUST DEPLETED DEPTHS
      DO 39       IFX=1,600
      DO 39 METAL=1,3
      PHFCTR=PHI(METAL)
      IF(FLUXES(METAL,IFX).GT.0)PHFCTR=1.
39    DELTA(METAL,IFX)=DELTA(METAL,IFX)+DTIME/PHFCTR*
     +FLUXES(METAL,IFX)/DENSM*3600.
      IF(LNUM.GT.3)GO TO 3909
C     IF THIS IS NOT A UW LOOP (LNUM 1,2,OR 3) GO TO 3909
      DO 3908 IFX=1,40
      DO 3908 METAL=1,3
      DO 3908 ISECT=1,4
      PHFCTR=PHI(METAL)
      IF(FLUXTS(METAL,IFX,ISECT).GT.0)PHFCTR=1.
3908  DELTTS(METAL,IFX,ISECT)=DELTTS(METAL,IFX,ISECT)
     ++DTIME/PHFCTR*FLUXTS(METAL,IFX,ISECT)/DENSM*3600.
3909  TIME=TIME+DTIME
      TIMEDA=TIME/24.
      DO 3910 I3300=1,3
      DO 3910 J3300=1,600
C     CHANGE CM TO MICRONS
      IF(I3300.NE.1)DELMIC(I3300+2,J3300)=10000.*
     +(DELTA(I3300,J3300)-DELTA(1,J3300))
3910  DELMIC(I3300,J3300)=10000.*DELTA(I3300,J3300)
      DO 391                             IXT=1,30
      IXTEN=IXT*20
      IXTM18=IXTEN-18
391   WRITE(6,392)(ISECT,IXT,TIME,TIMEDA,((DELMIC(IXJ,IXY),
     +IXY=IXTM18,IXTEN,2),IXJ=1,5))
392   FORMAT(/,"X",I1,"=",I4,"M",F6.0,"HRS,(",F5.0,"DAYS), MICRONS
     +(FE,CR,NI, CR-FE,NI-FE:",/,5(10F7.3,/))
3923   FORMAT(/,"X",I1,"=",F4.1,"M",F6.0,"HRS,(",F5.0,"DAYS),
     +MICRONS (FE,CR,NI, CR-FE,NI-FE:",/,5(10F7.3,/))
C     IF THIS IS A UW LOOP, WRITE OUT THICKNESSES IN TEST SECTIONS
C     OTHERWISE SKIP TO STATEMENT 393
      IF(LNUM.GT.3)GO TO 393
      WRITE(6,3933)
3933  FORMAT(" THICKNESSES OF SOLID PHASE DEPLETIONS IN TEST
     +SECTIONS FOLLOW:",/)
      DO 3931 I20=1,3
      DO 3931 J20=1,40
      DO 3931 ISECT=1,4
C     CHANGE CM TO MICRONS
```

```
      IF(I20.NE.1)DELMTS(I20+2,J20,ISECT)=10000.*
     +(DELTTS(I20,J20,ISECT)-DELTTS(1,J20,ISECT))
 3931 DELMTS(I20,J20,ISECT)=10000.*DELTTS(I20,J20,ISECT)
      DO 3932 ISECT=1,4
      DO 3932       IXT=1,4
      IXTP2=IXT/2+2
      XXTP2=IXT/2.+2.
      IXTEN=IXT*10
      IXTM9=IXTEN-9
 3932 WRITE(6,3923)(ISECT,XXTP2,TIME,TIMEDA,((DELMTS(IXJ,IXY,
     +ISECT),IXY=IXTM9,IXTEN),IXJ=1,5))
C
 393  IF(ITLAST.NE.0.AND.ITIME.NE.1)GO TO 43
C
C     SET FLAG ITLAST AND ITERATE ONE LAST TIME
C     IF PRINTOUT IS MADE (WITH EXTENDED PROGRAM) IT IS MADE NOW
 40   FORMAT(" ITERATION #",I3,", INIT CONC=",E14.6,",
     +FINAL=",E14.6,",(",F10.5,"PPM.)")
      ITLAST=1
      IW=NNLAST+1
      IF(NNLAST.NE.1.AND.ITIME.NE.1)GO TO  22
      IF(TIME.LE.0)WRITE(6,41)
      IF(TIME.LE.0)WRITE(6, 42)FLXNAM(IFLXX),FLXNAM(IFLXX)
  41   FORMAT(" FOLLOWING TABLE SHOWS AXIAL DISTANCE X (CM),",/,
     +"  TEMP T (C), CONCENTRATION AND SOLUBILITY C AND S (GMOL/CM3)
     +,",/," WALL FLUX N (NEG IS LOSS MG/CM2/MONTH), VEL V (CM/S).",
     +/," DIAM D (CM), ANNULUS I.D. OR PLATE WIDTH W (CM), L/D.")
  42  FORMAT(" SCHMIDT,REYNOLDS,NUSSELT NUMBERS, DIFFUSIVITY,MTC ",
     + "CGS,DELTA C, 4K/DV ",A4,
     +//,"    X  TEMP CONCENTN SOLUBILTY FLUX  VEL  DIAM W
     +    L/D  SCHM REYNLD NUSSELT  DFFUSVTY MTC(CGS) DELTA C",
     + "  4K/DV",A4)
      IF(TIME.LT.ETIME.OR.ETIME.EQ.0)GO TO  22
C
C
 43    ITLAST=0
      YI(1,LNUM)=Y(1)
      YI(2,LNUM)=Y(2)
      YI(3,LNUM)=Y(3)
      IF(IW.NE.2)GO TO  44
      CALL GRACE(0.)
      CALL COMPLX
      CALL NOBRDR
      CALL TITLE(1H ,1,"AXIAL POSITION, METERS$",100,1H ,1,6.,8.)
      CALL GRAF(0.,.06*A(11,LNUM),.32*A(11,LNUM),0.,1.,10.)
      CALL DFRAME
      CALL CURVE(XDRAW,YDR1,IXDRAW,6)
      CALL CURVE (XDRAW,YDR9,IXDRAW,6)
      CALL CURVE(XDRAW,YDR6,IXDRAW,6)
      CALL CURVE(XDRAW,YDR8,IXDRAW,6)
      CALL CURVE(XDRAW,YDR5,IXDRAW,6)
      CALL CURVE(XDRAW,YDR10,IXDRAW,6)
      ITHIGH=TE(200.)-273.
      ITLOW=TE(1900.)-273.
      CALL MESSAG("TEMPS:$",100,4.,.2)
      CALL INTNO(ITHIGH,"ABUT","ABUT")
      CALL MESSAG("-$",100,"ABUT","ABUT")
      CALL INTNO(ITLOW,"ABUT","ABUT")
      CALL LEGEND(IPAK1,6,4.,6.)
      CALL ENDPL(0)
```

```
      CALL TITLE(1H ,1,"AXIAL POSITION, METERS$",100,1H ,1,6.,8.)
      CALL GRAF(0.,.06*A(11,LNUM),.32*A(11,LNUM),0.,SC10,SCALE)
      CALL DFRAME
      CALL CURVE(XDRAW,YDR3,IXDRAW,6)
      CALL CURVE(XDRAW,YDR2,IXDRAW,6)
      CALL CURVE(XDRAW,YDR4,IXDRAW,6)
      CALL MESSAG("TEMPS:$",100,4.,.2)
      CALL INTNO(ITHIGH,"ABUT","ABUT")
      CALL MESSAG("-$",100,"ABUT","ABUT")
      CALL INTNO(ITLOW,"ABUT","ABUT")
      CALL LEGEND(IPAK2,3,4.,6.)
      CALL ENDPL(0)
      CALL RESET("COMPLX")
      CALL LINES("V = 1.36 M/S$",IVELS,1)
      CALL LINES("V =  .96 M/S$",IVELS,2)
      CALL LINES("V =  .65 M/S$",IVELS,3)
      CALL LINES("V =  .45 M/S$",IVELS,4)
      CALL COMPLX
      CALL MIXALF("INSTR")
      DO 1311 IPLOT = 2,3
      CALL TITLE(1H ,1,
     +"DOWNSTREAM POSITION, X/D$",100,"MASS LOSS RATE, G/
     +M(E)2(EX)/S * 10(E)+5(EX)$",100,6.,8.)
      CALL HEADIN("316 STAINLESS STEEL MASS LOSS$",100,3,2)
      CALL HEADIN("IN LIQUID LITHIUM$",100,3,2)
C     DETERMINE ROUNDED VALUE FOR MAXIMUM FLUX, FOR GRAPH
      FLXMAX=0.
      DO 12010 NZPOST=21,29
      ZPOSIT=(NZPOST-20.5)*5./.616
      XDRAW(NZPOST-20)=ZPOSIT
C     THEORY FLUXES IN T.SECTION, 1-45 CM FROM STRINGER INLET
      DO 12010 ISECT=1,4
      IF(FLUXTS(1,NZPOST,ISECT).LT.FLXMAX)FLXMAX=
     +FLUXTS(1,NZPOST,ISECT)
12010 YDRAW(NZPOST-20,ISECT)=-FLUXTS(1,NZPOST,ISECT)*PHISUM*
     +1.E9*AMW(1)
C     FLXMAX=-FLXMAX*1.E9*AMW(1)*PHISUM
      FLXMAX=-1.5*FLXEXP(1,1,LNUM)*AMW(1)*1.E9
      IFLXMX=FLXMAX/.05
      FLIMIT=.05*(IFLXMX+1.)
      FLXSPC=.05
      IF(IFLXMX.GT.20)FLXSPC=.1
      IF(IPLOT.NE.3)CALL GRAF(0.,10.,70.,0.,FLXSPC,FLIMIT)
      FLMIT1=FLIMIT/3.
      IF(IPLOT.EQ.3)CALL LOGLOG(8.,6.,FLMIT1,12.)
      CALL DFRAME
C
C
      CALL MARKER(1)
      CALL CURVE(XDRAW,YDRAW(1,1),9,-1)
      CALL MARKER(4)
      CALL CURVE(XDRAW,YDRAW(1,4),9,-1)
      CALL MARKER(2)
      CALL CURVE(XDRAW,YDRAW(1,2),9,-1)
      CALL MARKER(3)
      CALL CURVE(XDRAW,YDRAW(1,3),9,-1)
      CALL LEGEND(IVELS,4,4,1)
      IF(IPLOT.EQ.3)CALL MESSAG("LOG-LOG PLOT$",100,.2,1.5)
      IF(LAMTUR.EQ.-3)CALL MESSAG("X**-1/3 THEORY$",100,.2,1.0)
      IF(LAMTUR.EQ.-2)CALL MESSAG("X**-1/2 THEORY$",100,.2,1.0)
```

```
      CALL MESSAG("MEAN RATES:AVG ERR=$",100,.2,.7)
      IPC=ABCD
      CALL INTNO(IPC,"ABUT","ABUT")
      CALL MESSAG("%$",100,"ABUT","ABUT")
      CALL MESSAG("SOL@500C=EXP($",100,.2,.4)
      SOLWRI=A(15,LNUM)
      CALL REALNO(SOLWRI,1,"ABUT","ABUT")
671   CALL MESSAG("SHIFTS=$",100,.2,.1)
      CALL REALNO(ZEXTRA(1),1,"ABUT","ABUT")
674   CALL MESSAG(",$",100,"ABUT","ABUT")
      CALL REALNO(ZEXTRA(4),1,"ABUT","ABUT")
676   CALL MESSAG(",$",100,"ABUT","ABUT")
      CALL REALNO(ZEXTRA(2),1,"ABUT","ABUT")
678   CALL MESSAG(",$",100,"ABUT","ABUT")
      CALL REALNO(ZEXTRA(3),1,"ABUT","ABUT")
      ITHIGH=TE(200.)-273.
      ITLOW=TE(1900.)-273.
      CALL MESSAG("TEMPS:$",100,4.,.2)
      CALL INTNO(ITHIGH,"ABUT","ABUT")
      CALL MESSAG("-$",100,"ABUT","ABUT")
      CALL INTNO(ITLOW,"ABUT","ABUT")
1311  CALL ENDPL(0)
C
C
C
 44  IW=0
 46    CONTINUE
      PPM=Y(1)*AMW(1)*2.E+6
C     WRITE(6,40)ITER,YO,Y(1),PPM
 48   FORMAT("  SOLUTION TOOK ",I3,"ITERATIONS.")
      RETURN
C
C
 50    H=HO
C      IF X IS AT LOOP END  SOLUTION IS DONE
       IF(X.GT.2800..AND.ISECT.EQ.5)GO TO 30
C      IF ISPLIT.EQ.3 AND THIS T.SECT. 1,2, OR 3;TAKE NEXT T.SECT.
       IF(ISPLIT.EQ.3.AND. ISECT.LT.4)ISPLIT = 2
       IF(ISPLIT.EQ.3.AND.ISECT.EQ.4)GO TO 52
       IF(ISPLIT.EQ.2. AND. X.GT.300.)GO TO 52
C      IF ISPLIT EQ 2, WE ARE AT X=300 ;BEGIN SUPERPOSITION
C         SOLUTION IN THE COUPON SECTION
       IF(ISPLIT.EQ.2)CALL LAMSUP(Y,IW,XZ)
       IF(ISPLIT.EQ.2.AND.XZ.LT.400.)X=XZ
      XM300=X-300.
      XDIVDD=(X-300.)/.616
       IF(ISPLIT.EQ.2.AND.XZ.LT.400..AND.IW.EQ.2)WRITE(6,501)
      +RECRIT,XM300,XDIVDD,ISECT
501    FORMAT(" LENGTH REYNOLDS NUMBER=",F7.0," AT",F4.0,"CM",
      +"(",F4.0,"DIAMS) INTO STRINGER #",I1)
       IF(ISPLIT.EQ.2.AND.XZ.LT.400.)ISPLIT=3
       IF(ISPLIT.EQ.3)GO TO 26
       IF(ISPLIT.EQ.2)GO TO 52
       IF(ISPLIT.NE.1)GO TO  26
       XSAVE=X
C      SAVE THE INLET CONCENTRATION AT THE FLOW SPLIT POINT
       DO 51 MET=1,NMETAL
51     YSAVE(MET)=Y(MET)
C      IF(ISPLIT.EQ.1)HO=100.
       ISPLIT=2
```

```
      DX=A(11,LNUM)/8.
      ISECT=0
C
52    ISECT=ISECT+1
      X=XSAVE
      DO 53 MET=1,NMETAL
C     SAVE THE OUTLET CONCENTRATION FOR THIS TEST SECTION
      YMIX(MET,ISECT)=Y(MET)
53    Y(MET)=YSAVE(MET)
      IF(ISECT.LT.5)GO TO 27
      HO=DX
      X=XSPLIT(3,LNUM)
      ISPLIT=4
C     STORE AVG. RATE OF 1ST 15 CM COUPONS (IZ=22,24=COUPONS 1-5OR6)
      DO 531 JS=1,4
      FLXTHY(1,JS,LNUM)=0.
      DO 531 IX=22,24
531    FLXTHY(1,JS,LNUM)=FLXTHY(1,JS,LNUM)+FLUXTS(1,IX,JS)*PHISUM/3.
      DO 54 MET=1,NMETAL
      Y(MET)=0
      DO  54 JS=1,4
 54   Y(MET)=Y(MET)+YMIX(MET,JS+1)*FSPLIT(JS,LNUM)
      DX=A(11,LNUM)/2.
      GO TO 27
 56   H=HO
      IF(ISPLIT.EQ.5)GO TO 30
C     IS X AT END OF LOOP (A SUB 5,LNUM)
      IF(X.GT.(A(5,LNUM)-.1))GO TO 30
C     USE SMALLER DX IN TEST ZONES
      IF(ISPLIT.EQ.1.OR.ISPLIT.EQ.3)DX=A(11,LNUM)/8.
      IF(ISPLIT.EQ.2.OR.ISPLIT.EQ.4)DX=A(11,LNUM)/2.
C     GOING INTO NEXT SPLIT ZONE
      ISPLIT=ISPLIT+1
C     LET HO BE DX FOR DIFFY Q SOLVER
      HO=DX
      GO TO 27
      END
C
      SUBROUTINE FCN(Y,X,N,YPRIME)
C     FOR N FUNCTIONS Y OF X, DETERMINES DERIVATIVES YPRIME
      INTEGER DOPT,TOPT
      REAL A(20,5),RKMASS,Y(5),YPRIME(5),RKMASC,RKMASN
      COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
     +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
     +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
     +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
     +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
     +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
     +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
     +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
     +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
     +,ZEXTRA(5),ABCD
      DATA THRMSS/.0478/
C     FOLLOWING STEPS FOR DIA FIND ID AND OD OF ANNULUS,
C     DIAA, IDAM, AND ALSO WID, THE WIDTH OF ANY RECTANULAR COUPON.
C     DATA ARE STORED IN FUNCTION ROUTINE DD.
C     IF DATA NEGATIVE, IMPLIES RECTANGULAR COUPON OF WIDTH A(10,LNUM)
C     IF DATA IS LARGER THAN 100CM, LARGER PART IS 10 TIMES ID (CM)
C        THEREFORE 2503.0 IS ANNULUS WITH ID OF 2.5 AND OD OF 3 CM.
C
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C####UNITS ARE IN CENTIMETERS, GRAMS, SECONDS
      XFCNDV=ZETSTP
      IXFCN=X/XFCNDV

      WID=0.
      DIAA=0.
      DIAM=DIA(X)
      IF(DIAM.LT.0.)WID=A(10,LNUM)
      DIAM=ABS(DIAM)
      IF(DIAM.LT.100.)GO TO 10
      IDIA=DIAM/100.
      DIAA=IDIA
      DIAA=DIAA/10.
      DIAM=DIAM-DIAA*1000.
C     FLOW IS MASS RATE FOR LOOP TIMES FLOW SPLIT FOR ISECT SECTION
10    FLOW=A(7,LNUM)*FSPLIT(ISECT,LNUM)
      DMD=DIAM-DIAA
      IRETRN=0
      GO TO 21
      ENTRY SOLBIL(XARG)
      X=XARG
      IRETRN=1
21    T=TE(X)
      TX=T
      IF(DOPT.EQ.3)TX=A(1,LNUM)
C     SOL(1)=1./1400.*10.**(A(8,LNUM)-A(9,LNUM)/T)
131   SOL(1)=EXP(A(15,LNUM))*EXP(A(18,LNUM)/1.987*(1./773.-1./T))
      SOL(3)=54.*SOL(1)
C     SOL(3)=EXP(A(16,LNUM))*EXP(A(19,LNUM)/1.987*(1./773.-1./T))
      SOL(2)=SOL(1)
      IF(IRETRN.EQ.1)RETURN
      DENS=.515-.000101*(TX-473.)
      HEATCP=1.
      VISC=10.**(1.4936-.7368*ALOG10(TX)+109.95/TX)/100.
      VISCKN=VISC/DENS
      DIFF=1.38*TX/VISC/6./3.14159/1.25*10.**(-8)
      VEL=FLOW/3.14159/(DIAM**2-DIAA**2)/DENS*4.
C
C     DEFINE REYNOLDS NUMBER, L/D, SCHMIDT NUMBER
      REYN=DMD*VEL*DENS/VISC
      THRMLI=(.101+.0000294*TC)
      PRNDTL=VISC*HEATCP/THRMLI
C     CALCULATE PRESSURE GRADIENT (BLAUSIUS)
      DPDX=-DENS*VEL**2/DMD*.0791/REYN**.25
      RLAM=LAMTUR
      IF(LAMTUR.LT.0)RLAM=XLD
      SCHM=VISC/DENS/DIFF
C     TOTAL MOLAR CONCENTRATION IS INVERSE OF LITHIUM MOLAR VOLUME
      CONCEN=DENS/7.
      RNUSS=0.
      IF(REYN.GT.2300..AND.IHAUSN.EQ.1)RNUSS=
     +.116*(REYN**.66-125)*SCHM**.33*(1+RLAM**-.66)
      IF(RNUSS.NE.0)GO TO 13
      IF(.NOT.(REYN.GE.2100..AND.IHAUSN.EQ.2))GO TO 12
      ALNRE=ALOG(REYN)
      EXTURB=ALN26-.2*ALNRE
      EXLAM=ALN186-.6666*ALNRE-.3333*ALOG(RLAM)
      AKREYN=REALK/REYN**(1./BPOWER)
      RJFCTR=EXLAM*AKREYN+EXTURB*(1.-AKREYN)
      RNUSS=EXP(RJFCTR)*REYN*SCHM**.3333
```

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C!TURBJH=.026*REYN**-.2
C!TLAMJH=1.62*REYN**-.6666*RLAM**-.3333
C!REXP=REALK/REYN**(1./BPOWER)
C!AJH=TURBJH/(TURBJH/TLAMJH)**REXP
C!RNUSS=AJH*REYN*SCHM**.3333
        GO TO 13
12      IF(REYN.LT.CUTL)RNUSS=1.62*(REYN*SCHM/RLAM)**.33
C*********:NOTE USE OF LEVEQUE 1.62 RATHER THAN SIEDER TATE 1.86
        IF(REYN.GE.CUTH)RNUSS=.026*REYN**.8*SCHM**.33
13      RKMASS=RNUSS*DIFF/DMD
        TERM=4.*RKMASS/DMD/VEL
C       SET IXFCNT HIGH (500) AS FLAG ;DONT USE  EXCEPT IN TEST ZONES
        IF(ISECT.NE.5)IXFCNT=(X-200.)/XFCNDV
C
C       ASSUME FE ACTIVITY =1 AT SURFACE FOR SOL'N OR DEPOSITION
144     DELC(1)=1.*SOL(1)-Y(1)
C       IF THE CR AND FE DEPLETION DEPTH IS SAME, FE ACTIVITY
C          COEFFICIENT IS NOT UNITY
        IF(ABS(DELTA(1,IXFCN+1)-DELTA(2,IXFCN+1))
       +.LE.1.E-8.AND.DELC(1).GT.0..AND.IXFCN.GE.40)
       +DELC(1)=SOL(1)*PHI(1)/(PHI(1)+PHI(2))-Y(1)
        IF(ABS(DELTTS(1,IXFCNT+1,ISECT)-DELTTS(2,IXFCNT+1,ISECT))
       +.LE.1.E-8.AND.DELC(1).GT.0..AND.IXFCNT.LT.40)
       +DELC(1)=SOL(1)*PHI(1)/(PHI(1)+PHI(2))-Y(1)
        FLUX(1)=-RKMASS*DELC(1)
        FLUXES(1,IXFCN+1)=FLUX(1)
        YPRIME(1)=TERM*(1.+WID*2./DIAM/3.14159)*DELC(1)
        IF(WID.NE.0)DIAA=WID
        YPRIME(2)=0.
        YPRIME(3)=0.
        IXFCNT=500
        IF(ISECT.NE.5)IXFCNT=(X-200.)/XFCNDV
        IF(IXFCNT.LT.40)FLUXTS(1,IXFCNT+1,ISECT)=FLUXES(1,IXFCN+1)
        IF(ITIME.EQ.0)RETURN
        TORTUO=.3333
C       ASSUME UNITY ACTIVITY OF CHROMIUM FOR DEPOSITION
C       ASSUME ACT. COEFF. = %CR IN CR-FE (316SS WITHOUT NI)
        DELC(2)=SOL(2)-Y(2)
        IF(DELC(2).GT.0.0)DELC(2)=SOL(2)*(PHI(2)/(PHI(1)+PHI(2)))-Y(2)
        IF(DELC(2).GT.0.0)DELDL1=DELTA(1,IXFCN+1)-DELTA(2,IXFCN+1)
        IF(DELC(2).GT.0..AND.IXFCNT.LT.20)DELDL1=DELTTS(1,IXFCNT+1,
       +ISECT)-DELTTS(2,IXFCNT+1,ISECT)
        IF(DELC(2).LE.0)DELDL1=0.
        RKMASC=1./(1./RKMASS+DELDL1/(DIFF*TORTUO*(PHI(2)+PHI(3))))
        FLUX(2)=-RKMASC*DELC(2)
        FLUXES(2,IXFCN+1)=FLUX(2)
        IF(IXFCNT.LT.40)FLUXTS(2,IXFCNT+1,ISECT)=FLUX(2)
        YPRIME(2)=4.*RKMASC/DMD/VEL*(1.+WID*2./DIAM/3.14159)*DELC(2)
C       ASSUME UNIT ACTIVITY OF NICKEL FOR DEPOSITION
C       ASSUME ACTIVITY COEFFICIENT = % IN 316 SS FOR DISSOLUTION
        DELC(3)=SOL(3)-Y(3)
        IF(DELC(3).GT.0.)DELC(3)=SOL(3)*PHI(3)-Y(3)
        IF(DELC(3).GT.0.)DELDL2=DELTA(2,IXFCN+1)-DELTA(3,IXFCN+1)
        IF(DELC(3).GT.0..AND.IXFCNT.LT.20)DELDL2=DELTTS(2,IXFCNT+1,
       +ISECT)-DELTTS(3,IXFCNT+1,ISECT)
        RKMASN=1./(1./RKMASS+DELDL1/(DIFF*TORTUO*(PHI(2)+PHI(3)))+
       +DELDL2/(DIFF*TORTUO*PHI(3)))
        YPRIME(3)=4.*RKMASN/DMD/VEL*(1.+WID*2./DIAM/3.14159)*DELC(3)
        FLUX(3)=-RKMASN*DELC(3)
        FLUXES(3,IXFCN+1)=FLUX(3)
```

```
      IF(IXFCNT.LT.40)FLUXTS(3,IXFCNT+1,ISECT)=FLUX(3)
      RETURN
      END
C
C
C     ******************************************************************
C     ******************************************************************
      FUNCTION DIA(X)
      INTEGER DOPT,TOPT
      DIMENSION A(20,5)
      COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
     +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
     +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
     +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
     +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
     +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
     +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
     +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
     +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
     +,ZEXTRA(5),ABCD
C     UW ACTUAL 4.5' (1.37M) HEATER, ABOUT 4.5' LEADS(1.3M), 1.5'COUPONS,
C     1' LEADS(.46, .3),27' ECON (8.2M),22-23'RADIATOR(6.7M), 8.2M ECON,
C     10' PUMP LINE (3M)
C     UW REAL 54" HEATER(1.37 M) APPROX 5 FT METERS AND LEADINS(1.5M),
C     18INCHES COUPONS &12 " LEADOUTS (.46 & .3M), 27FT ECON(6.9M),
C     20FT RADIATOR(5.1M), 27 FT ECON(6.9M), 10FT PUMP(3M).
C     ARD LOOP APPROX. 4 HEATER, 1 LEADIN,1 HOT COUPON,
C            3 CONNECT, 1 WARM COUPON,
C        7 MORE HX, 4 RADIATOR ETC, 8 HX,1 MORE ELEMENT IN ARRAY.
C     ACTUAL ARD APPROX =
C
C
      DIMENSION DD(31,5),WTHCK(31,5)
C        CHECK THE 8*1.--IS INSIDE ECON TUBE 20 GAUGE=.035"?
      DATA WTHCK/2*.237,.049,.167,8*.035,7*.109,8*.109,4*.109,
     +2*.237,.049,.167,8*.035,7*.109,8*.109,4*.109,
     +2*.237,.049,.167,8*.035,7*.109,8*.109,4*.109,62*1./
      DATA DD/2*6.,1.35,.616,8*2.5,7*1.6,8*2503.25,4*1.6,
     +2*6.,1.35,.616,8*2.5,7*1.6,8*2503.25,4*1.6,
     +2*6.,1.35,.616,8*2.5,7*1.6,8*2503.25,4*1.6,
     +4*2.2,2.2,2002.2,3*2.2,2.44,2002.44,7*2.44,4*2.2,
     +8*2503.25,2.2,6*2.2,8*-2.2,6*2.2,8*-2.2,3*2.2/
      GO TO (1,2,1),DOPT
 1    DIA=A(4,LNUM)
      RETURN
 2    IX=X/A(11,LNUM)
      DIA=DD(IX+1,LNUM)
C     SET WALL THICKNESS
      WTHICK=WTHCK(IX+1,LNUM)*2.54
      IFLD=0
      IXN=X/A(11,LNUM)
      IF(IXN.NE.IXL.AND.DIA.EQ.A(4,LNUM))IFLD=1
      IF(DIA.NE.DIAML) IFLD=1
C     IFLD=1:  TRANSITION (CHANGE PIPE RADIUS, MIXING, ETC.)
      IXL=IXN
      DIAML=DIA
      RETURN
      END
C
C
```

```
C     ************************************************************
C     ************************************************************
      FUNCTION TE(X)
      INTEGER DOPT,TOPT
      DIMENSION A(20,5)
      COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
     +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
     +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
     +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
     +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
     +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
     +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
     +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
     +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
     +,ZEXTRA(5),ABCD
      DIMENSION TSTAND(31,5), QLOSSS(31,5), TT(31,5),XLDATA(31,5)
      DATA TSTAND/2*1.,397.,397.,14*1.,509.,551.,541.,556.,523.,521.,
     +488.,515.,563.,604.,496.,523.,485.,
     +2*1.,397.,397.,14*1.,509.,551.,541.,556.,523.,521.,
     +488.,515.,563.,604.,496.,523.,485.,
     +2*1.,397.,397.,14*1.,509.,551.,541.,556.,523.,521.,
     +488.,515.,563.,604.,496.,523.,485.,62*1./
      DATA QLOSSS/2*0.,.70,0.,8*0.,6*0.,.30,8*.46,4*.40,
     +2*0.,.70,0.,8*0.,6*0.,.30,8*.46,4*.40,
     +2*0.,.70,0.,8*0.,6*0.,.30,8*.46,4*.40,62*0./
      DATA TT/421.,435.,450.,441.,441.,419.,397.,375.,353.,331.,309.,
     +287.,266.,264.,262.,260.,259.,257.,256.,254.,275.,296.,317.,338.,
     +358.,379.,400.,4*421.,
     +480.,490.,500.,492.,492.,472.,453.,433.,414.,394.,
     +375.,355.,336.,334.,333.,332.,330.,329.,328.,327.,
     +347.,366.,386.,405.,425.,444.,464.,480.,3*480.,
     +431.,441.,450.,441.,441.,430.,419.,407.,396.,385.,373.,
     +363.,352.,351.,349.,348.,346.,345.,343.,342.,353.,364.,
     +376.,387.,398.,410.,421.,4*431.,
     +525.,528.,531.,534.,538.,538.,538.,538.,538.,534.,
     +530.,513.,495.,478.,460.,443.,425.,408.,390.,380.,
     +370.,365.,384.,403.,422.,441.,460.,479.,498.,520.,525.,
     +6*400.,425.,450.,475.,500.,525.,550.,
     +575.,600.,584.,566.,550.,533.,516.,500.,488.,475.,463.,
     +450.,438.,425.,412.,4*400./
      DATA XLDATA/0.5,100.,3*0.5,100.,200.,300.,400.,500.,600.,700.,
     +7*0.5,0.5,100.,200.,300.,400.,500.,600.,700.,4*0.5,
     +0.5,100.,3*0.5,100.,200.,300.,400.,500.,600.,700.,
     +7*0.5,0.5,100.,200.,300.,400.,500.,600.,700.,4*0.5,
     +0.5,100.,3*0.5,100.,200.,300.,400.,500.,600.,700.,
     +7*0.5,0.5,100.,200..300.,400.,500.,600.,700.,4*0.5,
     +0.5,50.,100.,150.,0.5,0.5,50.,100.,150.,200.,0.5,0.5,
     +50.,100.,150.,200.,250.,300.,0.5,50.,100.,150.,0.5,
     +50.,100.,150.,200.,250.,300.,350.,0.5,
     +0.5,8.,16.,24.,32.,40.,8*-1.,0.5,8.,16.,24.,32.,40.,
     +8*-1.,0.5,8.,16./
      GO TO (3,4),TOPT
3     TE=A(1,LNUM)+A(2,LNUM)*SIN((X-A(3,LNUM))/A(5,LNUM)*2.*3.14159)
      TC=TE-273.
      RETURN
4     INTX=X/A(11,LNUM)
      IX=INTX
      INTX=INTX*A(11,LNUM)
C     SET LOCAL L/D
      XLD=(XLDATA(IX+1,LNUM)+(X-INTX))/DMD
```

```
      IF(XLDATA(IX+1,LNUM).LT.0.)XLD=A(10,LNUM)/A(4,LNUM)
      QLOSS0=QLOSSS(IX+1,LNUM)
      TSTNBY=TSTAND(IX+1,LNUM)
      T1=TT(IX+1,LNUM)+273.
      T2=TT(IX+2,LNUM)+273.
C     SET LOCAL TEMPERATURE
      TE=(T2-T1)*(X-INTX)/A(11,LNUM)+T1
      TC=TE-273.
      RETURN
      END
C     ************************************************************
      SUBROUTINE LAMSUP(Y,IW,XZ)
      INTEGER DOPT,TOPT
      DIMENSION SLWNEW(5),AREAD(20),A(20,5),A0(20,5)
      COMMON/D/ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,ZETSTP,VISC,
     +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
     +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI(5,5),
     +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
     +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,XLD,DIFF,RNUSS,RKMASS,RECRIT,
     +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,ZSTEP,AINC(5,5)
     +,PHI(3),WTHICK,BPOWER,REALK,DENS,PHISUM,AMW(3),FLUXTS(3,40,5),
     +FLUXES(3,600),DELTA(3,600),FLUX(5),SOL(5),SOLTS(5,20,5),FLXMUL(10)
     +,UPSTRM(5),DENSM,TIME,DTIME,ETIME,ITIME,DELC(5),DELTTS(5,40,5)
     +,ZEXTRA(5),ABCD
      DIMENSION DCZET(5), Y(5),YPRIME(5)
      DIMENSION OFFSET(5), ACT(5), FLGUES(5), BRACKT(5),BRACKZ(5)
      Z=0.
      ACT(3)=PHI(3)
      ACT(2)=PHI(2)/(PHI(2)+PHI(1))
      ACT(1)=1.
      NMETAL=1
      IF(ITIME.NE.0)NMETAL=3
C     IF THIS IS THE FIRST TIME INTERVAL, THE ACTIVITY COEFFICIENTS
C        SHOULD BE SET EQUAL TO THE MOLE FRACTIONS
      IF(.NOT.(TIME.EQ.0..AND.ITIME.EQ.1))GO TO 1
      DO 1 MET=1,NMETAL
      ACT(MET)=PHI(MET)
1     CONTINUE
      XSTART=300.
      N=3
C     GET FLOW PROPERTIES FROM SUBROUTINE FCN
      CALL FCN(Y,XSTART,N,YPRIME)
C     SET BEGINNING OF THIS SUPERPOSITION SECTION
C     SOLUTION FOR SINGLE STEP CHANGE IN WALL POTENTIAL
C     HZ, HX SCALE FACTORS BOTH EQUAL UNITY FOR CYLINDRICAL PIPE
C     BETA  IS VELOCITY GRADIENT AT WALL, FOUND FROM FRICTION FACTOR
C     BETA=(1/2  DENS  VEL**2) F/VISC
C     F LAMINAR = 16/REYN     BETA LAMINAR = 8 VEL/ DIAM
C     F TURBULENT = .0791/REYN**.25 BETA=.039 *REYN**.75 VEL/DIAM
C     BETA LAMINAR FLAT PLATE=.332 * VEL**2 (DENS/VISC/VEL/Z)**.5
C     CALC. BETA,(WITHOUT Z**-.5 INCLUDED YET,FOR FLAT PLATE THEORY)
4     BETA=8.*VEL/DMD
      IF(LAMTUR.EQ.-2)BETA=.332/2.*VEL**2*(DENS/VISC/VEL)**.5
      CNSTNT=1.1198*DIFF/(9.*DIFF)**(1./3.)
      DIAZ=DMD
C
C
      DO 6 I6=1,20
      X=300.+(I6-1)*5.
      CALL SOLBIL(X)
```

```
          DO 6 J6=1,NMETAL
          BRACKT(J6)=0.
    6     SOLTS(J6,I6,ISECT)=ACT(J6)*SOL(J6)
C
C         STEP AHEAD, SET END POINT OF THIS SOLUTION STEP.
C
C
          IZFEND=40
    3     Z=Z+ZETSTP
          IF(Z.GT.100.)GO TO 65
C         RESET THE SUMMATION TO ZERO AND RESUM FOR THIS Z
          DO 7 IM=1,NMETAL
    7     BRACKT(IM)=0.
          ZETA=0.
          ZEND=Z
          IF((Z)*REYN/DMD.LT.RECRIT)GO TO 10
          Z=Z-ZETSTP
          IZFEND=Z/ZETSTP+20
          GO TO 65
C         ZETSTP IS SMALL STEP TAKEN IN SUPERPOSITION SOLUTION TO FIND
C         THE SOLUTION AT POINT Z.
C         X COORD. FROMPROPERTIES SUBROUTINE, STARTS UPSTREAM
C         OF HEATER. Z COORD. OF SUPERPOSITION STARTS DOWNSTREAM OF
C         OF TEST SECTIONS.
   10     ZETA=ZETA+ZETSTP
          IF(ZETA.GT.ZEND)GO TO 50
          IZ=ZETA/ZETSTP
   13     DO 12 IM=1,NMETAL
          IF(IZ.EQ.1)GO TO 11
          DCZET(IM)=SOLTS(IM,IZ,ISECT)-SOLTS(IM,IZ-1,ISECT)
   11     IF(IZ.EQ.1)DCZET(IM)=SOLTS(IM,1,ISECT)-Y(IM)
          ZLEFT=ZEND-(ZETA-ZETSTP)
C         SUPERPOSITION OF SMALL INCREMENTAL CHANGES IN WALL POTENTIAL
          IF(LAMTUR.NE.-2)BRACKZ(IM)=DCZET(IM)*(UPSTRM(ISECT)+BETA**.5*
         +(ZLEFT+ZEXTRA(ISECT)))**(-1./3.)
          IF(LAMTUR.EQ.-2)BRACKZ(IM)=DCZET(IM)*(UPSTRM(ISECT)+BETA**.5*
         +4./3.*((ZEND+ZEXTRA(ISECT))**.75-((ZETA-ZETSTP)+
         +ZEXTRA(ISECT))**.75))**(-1./3.)
   12     BRACKT(IM)=BRACKZ(IM)+BRACKT(IM)
          IF(ZETA. LT. ZEND)GO TO 10
   50     CONTINUE
          DO 51 IM51=1,NMETAL
          IF(LAMTUR.NE.-2)FLGUES(IM51)=-CNSTNT*BETA**.5*BRACKT(IM51)
          IF(LAMTUR.EQ.-2)FLGUES(IM51)=-CNSTNT*(BETA*ZEND**-.5)**.5*
         +BRACKT(IM51)
   51     CONTINUE
          IF(NMETAL.EQ.1)GO TO 60
C         FLUXES HAVE BEEN FOUND WITH AN GUESSED WALL POTENTIAL
C         WITH SOLID (PORE) RESISTANCE THE WALL POTENTIAL IS NOT
C         THE SOLUBILITY
C         NOW USE CALC. FLUX TO FIND BETTER GUESS AT WALL POTENTIAL
   53     PORE12=(DELTTS(1,IZ,ISECT)-DELTTS(2,IZ,ISECT))/
         +(PHI(2)+PHI(3))
   54     PORE23=(DELTTS(2,IZ,ISECT)-DELTTS(3,IZ,ISECT))/PHI(3)
          TORTUO=.3333
          IF(PORE12.NE.0)ACT(1)=PHI(1)/(PHI(1)+PHI(2))
   55     SLWNEW(2)=SOL(2)*ACT(2)+FLGUES(2)/DIFF/TORTUO*PORE12
   56     SLWNEW(3)=SOL(3)*ACT(3)+FLGUES(3)/DIFF/TORTUO*(PORE12+PORE23)
   57     IF(ABS(SLWNEW(2)-SOLTS(2,IZ,ISECT)).LE.EPSLIM.AND.
         +ABS(SLWNEW(3)-SOLTS(3,IZ,ISECT)).LE.EPSLIM)GO TO 60
```

```
      DO 58 IM=1,NMETAL
      IF(SLWNEW(IM).LE.Y(IM).AND.IM.NE.1)WRITE(6,5)ISECT,Z,IM,TIME
      IF(SLWNEW(IM).LE.Y(IM).AND.IM.NE.1)WRITE(59,5)ISECT,Z,IM,TIME
      IF(SLWNEW(IM).LE.Y(IM).AND.IM.NE.1)CALL QUIT(1)
5     FORMAT(" SECTION ",I2," AT Z=",F5.0," METAL #",I2," ATTEMPT
     + TO SET WALL CONCENTRATION BELOW STREAM CONCENTRATION",/,
     +" REDUCE TIME STEP OR CHECK NUMBERS: TIME =",F6.0)
      SOLTS(IM,IZ,ISECT)=SLWNEW(IM)
58    BRACKT(IM)=BRACKT(IM)-BRACKZ(IM)
      GO TO 13
60    DO 61 METAL=1,NMETAL
      FLUXTS(METAL,IZ+20,ISECT)=FLGUES(METAL)
      FLUXES(METAL,IZ+60)=FLGUES(METAL)
C     Y(I) IS STILL SET TO INPUT VALUE OF CONCENTRATIONS
C     NOW ADD THE CONTRIBUTION OF THE FLUX IN THE TEST SECTION
61    Y(METAL)=Y(METAL)-FLUXTS(METAL,IZ+20,ISECT)*4./DMD/VEL*ZETSTP
 28   FORMAT(1X,2F5.0,2E9.2,F6.2,F5.0,F5.2,F5.2,
     +2F5.0,F7.0,5E9.2,F6.2)
      IF(ITIME.NE.0)SUMFLX=FLUXES(1,IZ+60)*AMW(1)+FLUXES(2,IZ+60)
     +*AMW(2)+FLUXES(3,IZ+60)*AMW(3)
      IF(ITIME.EQ.0)SUMFLX=FLUXES(1,IZ+60)*PHISUM*AMW(1)
      FLUXX=SUMFLX*3600.*30.*24.*1000.
      FLUXXX=SUMFLX*FLXMUL(IFLXX)
      XZ=300.+Z
      DELC(1)=SOL(1)-Y(1)
      IF(IW.EQ.2.OR.ITIME.NE.0)WRITE
     +(6, 28)XZ,TC,Y(1),SOL(1),FLUXX,VEL,DIAM,DIAA,RLAM,SCHM,REYN
C    +,RNUSS,DIFF,RKMASS,DELC(1),TERM,FLUXXX
      GO TO 3
65    RETURN
      END
```

0. 0. 0. 0. 0. 0. 2 2-2 0 1 0 1 310102345 2-0
INIT GUESS CONCEN= 1.00E-09, TRIAL STEP= 2.00E-10
CONVERGE MASS BALANCE TO 3.00E-13
TEMP OPTION # 2, DIAM OPTION # 2, L/D=-2
LOOPS # 1 TO # 3 ARE TESTED.
REYNOLDS LOW BREAK=2300., HIGH=4500., HAUSEN(1)/S-T(0)= 2
FOR LOOPS TESTED THESE ARE BASIC PARAMETERS:

TMID	TDEL/2	ZRO CRS	NOM.DIA	LENGTH	WGHT.FCT	FLOW...	AEXP	ACTENG	COUP.WID	TABLE DX
623.00	100.00	2255.00	1.60	2957.00	1.00	47.50	-17.20	14200.00	0.	100.00
697.00	86.00	2255.00	1.60	2957.00	1.00	47.50	-17.20	14200.00	0.	100.00
669.50	53.50	2255.00	1.60	2957.00	1.00	47.50	-17.20	14200.00	0.	100.00

LITHIUM LOOPSYSTEMS PARAMETER OPTIMIZATION.
***DEVIATIONS NOT WEIGHTED BY VELOCITY OR TEMPERATURE.
ITERATION, AND PARAMETER 15-15 ESTIMATES & SUM SQRS OF DEVS
FIRST ROW IS SIZE OF PARAMETER TEST STEPS, AND DESIRED SSQ CONVERGENCE.
0 1.0000E-02 1.0000E-10
FOLLOWING TABLE SHOWS AXIAL DISTANCE X (CM),
TEMP T (C), CONCENTRATION AND SOLUBILITY C AND S (GMOL/CM3),
WALL FLUX N (NEG IS LOSS MG/CM2/MONTH), VEL V (CM/S),
DIAM D (CM), ANNULUS I.D. OR PLATE WIDTH W (CM), L/D,
SCHMIDT,REYNOLDS,NUSSELT NUMBERS, DIFFUSIVITY,MTC CGS,DELTA C, 4K/DV

X	TEMP	CONCENTN	SOLUBILTY	FLUX	VEL	DIAM	W	L/D	SCHM	REYNLD	NUSSELT	DFFUSVTY	MTC(CGS)	DELTA C	4K/DV	
12.	423.	5.63E-09	1.21E-08	-1.54	3.	6.00	0.	2.	65.	2793.	6.01E+01	1.13E-04	1.13E-03	6.52E-09	2.21E-04	0.
25.	425.	5.65E-09	1.25E-08	-1.60	3.	6.00	0.	4.	64.	2801.	5.95E+01	1.14E-04	1.13E-03	6.81E-09	2.20E-04	0.
37.	426.	5.67E-09	1.28E-08	-1.67	3.	6.00	0.	6.	64.	2809.	5.92E+01	1.14E-04	1.13E-03	7.12E-09	2.20E-04	0.
50.	428.	5.69E-09	1.31E-08	-1.74	3.	6.00	0.	8.	63.	2817.	5.90E+01	1.15E-04	1.13E-03	7.43E-09	2.20E-04	0.
62.	430.	5.71E-09	1.35E-08	-1.82	3.	6.00	0.	10.	63.	2824.	5.88E+01	1.15E-04	1.13E-03	7.75E-09	2.21E-04	0.
75.	431.	5.73E-09	1.38E-08	-1.90	3.	6.00	0.	13.	62.	2832.	5.87E+01	1.16E-04	1.13E-03	8.07E-09	2.21E-04	0.
87.	433.	5.75E-09	1.41E-08	-1.99	3.	6.00	0.	15.	62.	2840.	5.85E+01	1.17E-04	1.14E-03	8.40E-09	2.22E-04	0.
100.	435.	5.77E-09	1.45E-08	-2.08	3.	6.00	0.	17.	62.	2847.	5.85E+01	1.17E-04	1.14E-03	8.73E-09	2.23E-04	0.
113.	437.	5.80E-09	1.49E-08	-2.17	3.	6.00	0.	19.	61.	2856.	5.84E+01	1.18E-04	1.15E-03	9.10E-09	2.23E-04	0.
125.	439.	5.83E-09	1.53E-08	-2.27	3.	6.00	0.	21.	61.	2864.	5.83E+01	1.18E-04	1.15E-03	9.47E-09	2.24E-04	0.
138.	441.	5.85E-09	1.57E-08	-2.38	3.	6.00	0.	23.	60.	2872.	5.83E+01	1.19E-04	1.16E-03	9.85E-09	2.25E-04	0.
150.	443.	5.88E-09	1.61E-08	-2.48	3.	6.00	0.	25.	60.	2880.	5.83E+01	1.20E-04	1.16E-03	1.02E-08	2.26E-04	0.
163.	444.	5.91E-09	1.66E-08	-2.59	3.	6.00	0.	27.	59.	2889.	5.82E+01	1.20E-04	1.17E-03	1.06E-08	2.27E-04	0.
175.	446.	5.94E-09	1.70E-08	-2.70	3.	6.00	0.	29.	59.	2897.	5.82E+01	1.21E-04	1.17E-03	1.10E-08	2.28E-04	0.
188.	448.	5.97E-09	1.74E-08	-2.82	3.	6.00	0.	31.	58.	2905.	5.82E+01	1.22E-04	1.18E-03	1.15E-08	2.29E-04	0.
200.	450.	6.01E-09	1.79E-08	-30.39	68.	1.35	0.	8.	58.	12948.	1.96E+02	1.22E-04	1.78E-02	8.22E-09	7.76E-04	0.
212.	449.	6.10E-09	1.76E-08	-13.95	27.	1.35	0.	10.	58.	5145.	9.37E+01	1.22E-04	8.47E-03	7.91E-09	9.31E-04	0.
225.	448.	6.19E-09	1.73E-08	-13.37	27.	1.35	0.	19.	58.	5136.	9.37E+01	1.22E-04	8.44E-03	7.60E-09	9.28E-04	0.
237.	447.	6.28E-09	1.71E-08	-12.80	27.	1.35	0.	28.	59.	5127.	9.37E+01	1.21E-04	8.42E-03	7.30E-09	9.25E-04	0.
250.	446.	6.36E-09	1.68E-08	-12.25	27.	1.35	0.	37.	59.	5118.	9.38E+01	1.21E-04	8.39E-03	7.01E-09	9.23E-04	0.
262.	444.	6.44E-09	1.66E-08	-11.72	27.	1.35	0.	47.	59.	5110.	9.38E+01	1.20E-04	8.37E-03	6.72E-09	9.20E-04	0.
275.	443.	6.52E-09	1.63E-08	-11.20	27.	1.35	0.	56.	59.	5101.	9.38E+01	1.20E-04	8.34E-03	6.44E-09	9.18E-04	0.
288.	442.	6.59E-09	1.60E-08	-10.69	27.	1.35	0.	65.	60.	5092.	9.38E+01	1.20E-04	8.31E-03	6.17E-09	9.15E-04	0.
300.	441.	6.66E-09	1.58E-08	-41.84	129.	0.62	0.	1.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	5.90E-09	1.71E-03	0.
305.	441.	6.68E-09	1.58E-08	-14.35	129.	0.62	0.	1.	60.	11141.						
310.	441.	6.69E-09	1.50E-08	-10.13	129.	0.62	0.	1.	60.	11141.						
315.	441.	6.70E-09	1.50E-08	-0.26	129.	0.62	0.	1.	60.	11141.						
320.	441.	6.71E-09	1.50E-08	-7.14	129.	0.62	0.	1.	60.	11141.						
LENGTH REYNOLDS NUMBER=450000. AT 20.CM(32.DIAMS) INTO STRINGER #1																
332.	441.	6.83E-09	1.58E-08	-40.61	129.	0.62	0.	54.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	5.73E-09	1.71E-03	0.
345.	441.	6.95E-09	1.58E-08	-39.75	129.	0.62	0.	74.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	5.61E-09	1.71E-03	0.
357.	441.	7.07E-09	1.58E-08	-38.91	129.	0.62	0.	94.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	5.49E-09	1.71E-03	0.
370.	441.	7.19E-09	1.58E-08	-38.09	129.	0.62	0.	114.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	5.37E-09	1.71E-03	0.
382.	441.	7.30E-09	1.58E-08	-37.28	129.	0.62	0.	135.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	5.26E-09	1.71E-03	0.
395.	441.	7.41E-09	1.58E-08	-36.50	129.	0.62	0.	155.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	5.15E-09	1.71E-03	0.

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400. 441. 7.45E-09 1.50E-08 -3.06   0. 2.50 0.     0.  60.  2745. 6.03E+01 1.19E-04 2.00E-03 5.10E-09 5.87E-04  0.
212. 449. 6.12E-09 1.76E-08 -7.35  13. 1.35 0.    10.  58.  2456. 4.95E+01 1.22E-04 4.47E-03 7.09E-09 1.03E-03  0.
225. 448. 6.21E-09 1.73E-08 -6.75  13. 1.35 0.    19.  58.  2452. 4.75E+01 1.22E-04 4.27E-03 7.50E-09 9.84E-04  0.
237. 447. 6.30E-09 1.71E-08 -6.29  13. 1.35 0.    28.  59.  2448. 4.62E+01 1.21E-04 4.15E-03 7.28E-09 9.56E-04  0.
250. 446. 6.39E-09 1.68E-08 -5.90  13. 1.35 0.    37.  59.  2443. 4.53E+01 1.21E-04 4.06E-03 6.98E-09 9.35E-04  0.
262. 444. 6.47E-09 1.66E-08 -5.55  13. 1.35 0.    47.  59.  2439. 4.46E+01 1.20E-04 3.98E-03 6.70E-09 9.17E-04  0.
275. 443. 6.54E-09 1.63E-08 -5.23  13. 1.35 0.    56.  59.  2435. 4.40E+01 1.20E-04 3.91E-03 6.42E-09 9.01E-04  0.
288. 442. 6.61E-09 1.60E-08 -4.92  13. 1.35 0.    65.  60.  2431. 4.34E+01 1.20E-04 3.85E-03 6.15E-09 8.86E-04  0.
300. 441. 6.68E-09 1.50E-08-23.07  62. 0.62 0.     1.  60.  5319. 9.73E+01 1.19E-04 1.80E-02 5.88E-09 1.98E-03  0.
305. 441. 6.71E-09 1.50E-08 -9.89  62. 0.62 0.     1.  60.  5319.
310. 441. 6.72E-09 1.50E-08 -6.97  62. 0.62 0.     1.  60.  5319.
315. 441. 6.74E-09 1.50E-08 -5.68  62. 0.62 0.     1.  60.  5319.
320. 441. 6.75E-09 1.50E-08 -4.91  62. 0.62 0.     1.  60.  5319.
325. 441. 6.76E-09 1.50E-08 -4.39  62. 0.62 0.     1.  60.  5319.
330. 441. 6.77E-09 1.50E-08 -4.00  62. 0.62 0.     1.  60.  5319.
335. 441. 6.78E-09 1.50E-08 -3.70  62. 0.62 0.     1.  60.  5319.
340. 441. 6.79E-09 1.50E-08 -3.46  62. 0.62 0.     1.  60.  5319.
345. 441. 6.80E-09 1.50E-08 -3.26  62. 0.62 0.     1.  60.  5319.
350. 441. 6.81E-09 1.50E-08 -3.09  62. 0.62 0.     1.  60.  5319.
LENGTH REYNOLDS NUMBER=450000. AT 50.CM( 81.DIAMS) INTO STRINGER #2
363. 441. 6.95E-09 1.50E-08-22.02  62. 0.62 0.   102.  60.  5319. 9.73E+01 1.19E-04 1.80E-02 5.61E-09 1.98E-03  0.
375. 441. 7.08E-09 1.50E-08-21.48  62. 0.62 0.   123.  60.  5319. 9.73E+01 1.19E-04 1.80E-02 5.40E-09 1.98E-03  0.
388. 441. 7.22E-09 1.50E-08-20.96  62. 0.62 0.   143.  60.  5319. 9.73E+01 1.19E-04 1.80E-02 5.34E-09 1.98E-03  0.
400. 441. 7.35E-09 1.50E-08 -5.88   4. 2.50 0.     0.  60.  1310. 1.14E+02 1.19E-04 5.42E-03 5.21E-09 2.31E-03  0.
212. 449. 6.15E-09 1.76E-08 -5.04   9. 1.35 0.    10.  58.  1693. 3.41E+01 1.22E-04 3.08E-03 7.86E-09 1.03E-03  0.
225. 448. 6.24E-09 1.73E-08 -3.87   9. 1.35 0.    19.  58.  1690. 2.73E+01 1.22E-04 2.46E-03 7.55E-09 8.21E-04  0.
237. 447. 6.31E-09 1.71E-08 -3.26   9. 1.35 0.    28.  59.  1688. 2.40E+01 1.21E-04 2.15E-03 7.27E-09 7.19E-04  0.
250. 446. 6.37E-09 1.68E-08 -2.85   9. 1.35 0.    37.  59.  1685. 2.18E+01 1.21E-04 1.95E-03 7.00E-09 6.53E-04  0.
262. 444. 6.42E-09 1.66E-08 -2.54   9. 1.35 0.    47.  59.  1682. 2.03E+01 1.20E-04 1.81E-03 6.74E-09 6.06E-04  0.
275. 443. 6.47E-09 1.63E-08 -2.30   9. 1.35 0.    56.  59.  1679. 1.92E+01 1.20E-04 1.70E-03 6.49E-09 5.69E-04  0.
288. 442. 6.52E-09 1.60E-08 -2.18   9. 1.35 0.    65.  60.  1676. 1.82E+01 1.20E-04 1.62E-03 6.24E-09 5.40E-04  0.
300. 441. 6.56E-09 1.50E-08-17.50  43. 0.62 0.     1.  60.  3667. 7.23E+01 1.19E-04 1.40E-02 6.00E-09 2.14E-03  0.
305. 441. 6.59E-09 1.50E-08 -8.32  43. 0.62 0.     1.  60.  3667.
310. 441. 6.61E-09 1.50E-08 -5.86  43. 0.62 0.     1.  60.  3667.
315. 441. 6.63E-09 1.50E-08 -4.78  43. 0.62 0.     1.  60.  3667.
320. 441. 6.65E-09 1.50E-08 -4.13  43. 0.62 0.     1.  60.  3667.
325. 441. 6.66E-09 1.50E-08 -3.69  43. 0.62 0.     1.  60.  3667.
330. 441. 6.67E-09 1.50E-08 -3.36  43. 0.62 0.     1.  60.  3667.
335. 441. 6.68E-09 1.50E-08 -3.11  43. 0.62 0.     1.  60.  3667.
340. 441. 6.69E-09 1.50E-08 -2.90  43. 0.62 0.     1.  60.  3667.
345. 441. 6.70E-09 1.50E-08 -2.73  43. 0.62 0.     1.  60.  3667.
350. 441. 6.71E-09 1.50E-08 -2.59  43. 0.62 0.     1.  60.  3667.
355. 441. 6.72E-09 1.50E-08 -2.47  43. 0.62 0.     1.  60.  3667.
360. 441. 6.73E-09 1.50E-08 -2.36  43. 0.62 0.     1.  60.  3667.
365. 441. 6.74E-09 1.50E-08 -2.27  43. 0.62 0.     1.  60.  3667.
370. 441. 6.75E-09 1.50E-08 -2.18  43. 0.62 0.     1.  60.  3667.
375. 441. 6.75E-09 1.50E-08 -2.11  43. 0.62 0.     1.  60.  3667.
LENGTH REYNOLDS NUMBER=450000. AT 75.CM(122.DIAMS) INTO STRINGER #3
388. 441. 6.91E-09 1.50E-08-16.42  43. 0.62 0.   143.  60.  3667. 7.21E+01 1.19E-04 1.39E-02 5.65E-09 2.13E-03  0.
400. 441. 7.06E-09 1.50E-08 -5.50   3. 2.50 0.     0.  60.   904. 1.01E+02 1.19E-04 4.79E-03 5.50E-09 2.97E-03  0.
212. 449. 6.11E-09 1.76E-08-10.54  19. 1.35 0.    10.  58.  3632. 7.09E+01 1.22E-04 6.40E-03 7.90E-09 9.97E-04  0.
225. 448. 6.21E-09 1.73E-08-10.08  19. 1.35 0.    19.  58.  3626. 7.08E+01 1.22E-04 6.38E-03 7.59E-09 9.93E-04  0.
237. 447. 6.30E-09 1.71E-08 -9.65  19. 1.35 0.    28.  59.  3620. 7.08E+01 1.21E-04 6.36E-03 7.28E-09 9.90E-04  0.
250. 446. 6.39E-09 1.68E-08 -9.22  19. 1.35 0.    37.  59.  3614. 7.08E+01 1.21E-04 6.34E-03 6.99E-09 9.87E-04  0.
262. 444. 6.47E-09 1.66E-08 -8.81  19. 1.35 0.    47.  59.  3608. 7.08E+01 1.20E-04 6.32E-03 6.70E-09 9.84E-04  0.
275. 443. 6.55E-09 1.63E-08 -8.41  19. 1.35 0.    56.  59.  3601. 7.08E+01 1.20E-04 6.30E-03 6.41E-09 9.81E-04  0.
288. 442. 6.63E-09 1.60E-08 -8.02  19. 1.35 0.    65.  60.  3595. 7.08E+01 1.20E-04 6.28E-03 6.13E-09 9.78E-04  0.
300. 441. 6.70E-09 1.50E-08-31.44  91. 0.62 0.     1.  60.  7866. 1.33E+02 1.19E-04 2.50E-02 5.86E-09 1.83E-03  0.
305. 441. 6.72E-09 1.50E-08-12.00  91. 0.62 0.     1.  60.  7866.
310. 441. 6.74E-09 1.50E-08 -8.47  91. 0.62 0.     1.  60.  7866.
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315.	441.	6.75E-09	1.58E-08	-6.90	91.	0.62	0.	1.	60.	7866.
320.	441.	6.76E-09	1.58E-08	-5.97	91.	0.62	0.	1.	60.	7866.
325.	441.	6.77E-09	1.58E-08	-5.33	91.	0.62	0.	1.	60.	7866.
330.	441.	6.78E-09	1.58E-08	-4.86	91.	0.62	0.	1.	60.	7866.
335.	441.	6.78E-09	1.58E-08	-4.50	91.	0.62	0.	1.	60.	7866.

LENGTH REYNOLDS NUMBER=450000. AT 35.CM(57.DIAMS) INTO STRINGER #4

348.	441.	6.91E-09	1.58E-08	-30.29	91.	0.62	0.	78.	60.	7866.	1.33E+02	1.19E-04	2.58E-02	5.64E-09	1.83E-03	0.
360.	441.	7.04E-09	1.58E-08	-29.60	91.	0.62	0.	98.	60.	7866.	1.33E+02	1.19E-04	2.58E-02	5.52E-09	1.83E-03	0.
373.	441.	7.17E-09	1.58E-08	-28.93	91.	0.62	0.	119.	60.	7866.	1.33E+02	1.19E-04	2.58E-02	5.39E-09	1.83E-03	0.
385.	441.	7.29E-09	1.58E-08	-28.28	91.	0.62	0.	139.	60.	7866.	1.33E+02	1.19E-04	2.58E-02	5.27E-09	1.83E-03	0.
398.	441.	7.41E-09	1.58E-08	-27.64	91.	0.62	0.	159.	60.	7866.	1.33E+02	1.19E-04	2.58E-02	5.15E-09	1.83E-03	0.
400.	441.	7.43E-09	1.58E-08	-6.59	6.	2.50	0.	0.	60.	1938.	1.29E+02	1.19E-04	6.17E-03	5.13E-09	1.78E-03	0.
412.	438.	7.40E-09	1.52E-08	-5.53	20.	2.50	0.	5.	61.	6868.	1.20E+02	1.18E-04	5.67E-03	4.68E-09	4.60E-04	0.
425.	435.	7.43E-09	1.46E-08	-4.91	20.	2.50	0.	10.	61.	6839.	1.20E+02	1.17E-04	5.63E-03	4.19E-09	4.57E-04	0.
437.	433.	7.45E-09	1.40E-08	-4.33	20.	2.50	0.	15.	62.	6810.	1.20E+02	1.16E-04	5.59E-03	3.72E-09	4.54E-04	0.
450.	430.	7.47E-09	1.35E-08	-3.77	20.	2.50	0.	20.	63.	6781.	1.20E+02	1.15E-04	5.54E-03	3.27E-09	4.51E-04	0.
462.	427.	7.49E-09	1.30E-08	-3.24	20.	2.50	0.	25.	64.	6752.	1.20E+02	1.14E-04	5.50E-03	2.83E-09	4.47E-04	0.
475.	425.	7.50E-09	1.25E-08	-2.74	20.	2.50	0.	30.	64.	6723.	1.20E+02	1.14E-04	5.46E-03	2.41E-09	4.44E-04	0.
487.	422.	7.52E-09	1.20E-08	-2.26	20.	2.50	0.	35.	65.	6694.	1.20E+02	1.13E-04	5.42E-03	2.00E-09	4.41E-04	0.
500.	419.	7.53E-09	1.15E-08	-1.80	20.	2.50	0.	40.	66.	6664.	1.20E+02	1.12E-04	5.37E-03	1.61E-09	4.38E-04	0.
512.	416.	7.53E-09	1.10E-08	-1.37	20.	2.50	0.	45.	67.	6635.	1.20E+02	1.11E-04	5.33E-03	1.23E-09	4.35E-04	0.
525.	413.	7.54E-09	1.06E-08	-0.96	20.	2.50	0.	50.	68.	6606.	1.20E+02	1.10E-04	5.29E-03	8.72E-10	4.32E-04	0.
537.	411.	7.54E-09	1.01E-08	-0.57	20.	2.50	0.	55.	68.	6577.	1.21E+02	1.09E-04	5.25E-03	5.23E-10	4.28E-04	0.
550.	408.	7.54E-09	9.72E-09	-0.20	20.	2.50	0.	60.	69.	6547.	1.21E+02	1.08E-04	5.21E-03	1.88E-10	4.25E-04	0.
562.	405.	7.55E-09	9.32E-09	0.15	20.	2.50	0.	65.	70.	6518.	1.21E+02	1.07E-04	5.17E-03	-1.35E-10	4.22E-04	0.
575.	403.	7.54E-09	8.92E-09	0.47	20.	2.50	0.	70.	71.	6489.	1.21E+02	1.06E-04	5.12E-03	-4.44E-10	4.19E-04	0.
587.	400.	7.54E-09	8.55E-09	0.79	20.	2.50	0.	75.	72.	6459.	1.21E+02	1.05E-04	5.08E-03	-7.42E-10	4.16E-04	0.
600.	397.	7.54E-09	8.18E-09	1.08	20.	2.50	0.	80.	73.	6430.	1.21E+02	1.04E-04	5.04E-03	-1.03E-09	4.13E-04	0.
612.	394.	7.53E-09	7.83E-09	1.36	20.	2.50	0.	85.	74.	6401.	1.21E+02	1.03E-04	5.00E-03	-1.30E-09	4.10E-04	0.
625.	392.	7.52E-09	7.49E-09	0.03	20.	2.50	0.	90.	75.	6371.	1.21E+02	1.02E-04	4.96E-03	-3.15E-11	4.07E-04	0.
637.	389.	7.52E-09	7.16E-09	0.37	20.	2.50	0.	95.	76.	6342.	1.21E+02	1.02E-04	4.92E-03	-3.58E-10	4.03E-04	0.
650.	386.	7.52E-09	6.85E-09	0.68	20.	2.50	0.	100.	77.	6312.	1.21E+02	1.01E-04	4.88E-03	-6.71E-10	4.00E-04	0.
662.	383.	7.52E-09	6.54E-09	0.98	19.	2.50	0.	105.	78.	6283.	1.21E+02	9.98E-05	4.84E-03	-9.71E-10	3.97E-04	0.
675.	381.	7.51E-09	6.25E-09	1.26	19.	2.50	0.	110.	79.	6253.	1.21E+02	9.89E-05	4.80E-03	-1.26E-09	3.94E-04	0.
687.	378.	7.50E-09	5.97E-09	1.52	19.	2.50	0.	115.	80.	6223.	1.21E+02	9.80E-05	4.76E-03	-1.53E-09	3.91E-04	0.
700.	375.	7.49E-09	5.70E-09	1.77	19.	2.50	0.	120.	81.	6194.	1.21E+02	9.72E-05	4.72E-03	-1.80E-09	3.88E-04	0.
712.	372.	7.49E-09	5.44E-09	2.00	19.	2.50	0.	125.	82.	6164.	1.21E+02	9.63E-05	4.68E-03	-2.05E-09	3.85E-04	0.
725.	370.	7.47E-09	5.18E-09	2.22	19.	2.50	0.	130.	83.	6134.	1.22E+02	9.54E-05	4.64E-03	-2.29E-09	3.82E-04	0.
737.	367.	7.46E-09	4.94E-09	2.42	19.	2.50	0.	135.	84.	6105.	1.22E+02	9.46E-05	4.60E-03	-2.52E-09	3.79E-04	0.
750.	364.	7.45E-09	4.71E-09	2.61	19.	2.50	0.	140.	85.	6075.	1.22E+02	9.37E-05	4.56E-03	-2.74E-09	3.76E-04	0.
762.	361.	7.44E-09	4.49E-09	2.78	19.	2.50	0.	145.	86.	6045.	1.22E+02	9.28E-05	4.52E-03	-2.95E-09	3.73E-04	0.
775.	359.	7.42E-09	4.27E-09	2.94	19.	2.50	0.	150.	88.	6015.	1.22E+02	9.20E-05	4.48E-03	-3.15E-09	3.70E-04	0.
787.	356.	7.41E-09	4.06E-09	3.10	19.	2.50	0.	155.	89.	5986.	1.22E+02	9.11E-05	4.44E-03	-3.34E-09	3.67E-04	0.
800.	353.	7.39E-09	3.87E-09	3.24	19.	2.50	0.	160.	90.	5956.	1.22E+02	9.03E-05	4.41E-03	-3.53E-09	3.64E-04	0.
812.	350.	7.38E-09	3.68E-09	3.37	19.	2.50	0.	165.	91.	5926.	1.22E+02	8.94E-05	4.37E-03	-3.70E-09	3.61E-04	0.
825.	348.	7.36E-09	3.49E-09	3.49	19.	2.50	0.	170.	93.	5896.	1.22E+02	8.86E-05	4.33E-03	-3.87E-09	3.58E-04	0.
837.	345.	7.34E-09	3.32E-09	3.59	19.	2.50	0.	175.	94.	5866.	1.22E+02	8.77E-05	4.29E-03	-4.02E-09	3.55E-04	0.
850.	342.	7.32E-09	3.15E-09	3.69	19.	2.50	0.	180.	95.	5836.	1.22E+02	8.69E-05	4.25E-03	-4.17E-09	3.52E-04	0.
862.	339.	7.31E-09	2.99E-09	3.79	19.	2.50	0.	185.	97.	5806.	1.22E+02	8.61E-05	4.21E-03	-4.31E-09	3.49E-04	0.
875.	337.	7.29E-09	2.84E-09	3.87	19.	2.50	0.	190.	98.	5776.	1.22E+02	8.52E-05	4.18E-03	-4.45E-09	3.46E-04	0.
887.	334.	7.27E-09	2.69E-09	3.94	19.	2.50	0.	195.	99.	5746.	1.23E+02	8.44E-05	4.14E-03	-4.58E-09	3.43E-04	0.
900.	331.	7.25E-09	2.55E-09	4.01	19.	2.50	0.	200.	101.	5716.	1.23E+02	8.36E-05	4.10E-03	-4.70E-09	3.40E-04	0.
912.	328.	7.23E-09	2.42E-09	4.07	19.	2.50	0.	205.	102.	5686.	1.23E+02	8.28E-05	4.06E-03	-4.81E-09	3.37E-04	0.
925.	326.	7.21E-09	2.29E-09	4.12	19.	2.50	0.	210.	104.	5656.	1.23E+02	8.20E-05	4.02E-03	-4.92E-09	3.34E-04	0.
937.	323.	7.19E-09	2.17E-09	4.17	19.	2.50	0.	215.	105.	5626.	1.23E+02	8.11E-05	3.99E-03	-5.02E-09	3.31E-04	0.
950.	320.	7.16E-09	2.05E-09	4.21	19.	2.50	0.	220.	107.	5595.	1.23E+02	8.03E-05	3.95E-03	-5.12E-09	3.28E-04	0.
962.	317.	7.14E-09	1.94E-09	4.24	19.	2.50	0.	225.	109.	5565.	1.23E+02	7.95E-05	3.91E-03	-5.21E-09	3.26E-04	0.
975.	315.	7.12E-09	1.83E-09	4.27	19.	2.50	0.	230.	110.	5535.	1.23E+02	7.87E-05	3.88E-03	-5.29E-09	3.23E-04	0.
987.	312.	7.10E-09	1.73E-09	4.30	19.	2.50	0.	235.	112.	5505.	1.23E+02	7.79E-05	3.84E-03	-5.37E-09	3.20E-04	0.
1000.	309.	7.08E-09	1.63E-09	4.32	19.	2.50	0.	240.	114.	5474.	1.23E+02	7.71E-05	3.80E-03	-5.45E-09	3.17E-04	0.

1012.	306.	7.06E-09	1.54E-09	4.33	19.	2.50	0.	245.	115.	5444.	1.23E+02	7.63E-05	3.77E-03-5.52E-09	3.14E-04	0.
1025.	304.	7.04E-09	1.45E-09	4.34	19.	2.50	0.	250.	117.	5414.	1.23E+02	7.56E-05	3.73E-03-5.59E-09	3.11E-04	0.
1037.	301.	7.01E-09	1.37E-09	4.35	19.	2.50	0.	255.	119.	5383.	1.23E+02	7.48E-05	3.69E-03-5.65E-09	3.08E-04	0.
1050.	298.	6.99E-09	1.29E-09	4.35	19.	2.50	0.	260.	121.	5353.	1.24E+02	7.40E-05	3.66E-03-5.71E-09	3.05E-04	0.
1062.	295.	6.97E-09	1.21E-09	4.35	19.	2.50	0.	265.	123.	5323.	1.24E+02	7.32E-05	3.62E-03-5.76E-09	3.03E-04	0.
1075.	293.	6.95E-09	1.14E-09	4.34	19.	2.50	0.	270.	125.	5292.	1.24E+02	7.25E-05	3.59E-03-5.81E-09	3.00E-04	0.
1087.	290.	6.93E-09	1.07E-09	4.33	19.	2.50	0.	275.	127.	5262.	1.24E+02	7.17E-05	3.55E-03-5.86E-09	2.97E-04	0.
1100.	287.	6.91E-09	1.01E-09	4.32	19.	2.50	0.	280.	129.	5231.	1.24E+02	7.09E-05	3.51E-03-5.90E-09	2.94E-04	0.
1112.	284.	6.88E-09	9.48E-10	4.30	19.	2.50	0.	285.	131.	5202.	1.24E+02	7.02E-05	3.48E-03-5.94E-09	2.92E-04	0.
1125.	282.	6.86E-09	8.92E-10	4.29	19.	2.50	0.	290.	133.	5173.	1.24E+02	6.95E-05	3.45E-03-5.97E-09	2.89E-04	0.
1137.	279.	6.84E-09	8.39E-10	4.27	19.	2.50	0.	295.	135.	5143.	1.24E+02	6.88E-05	3.41E-03-6.00E-09	2.86E-04	0.
1150.	276.	6.82E-09	7.89E-10	4.25	19.	2.50	0.	300.	137.	5114.	1.24E+02	6.80E-05	3.38E-03-6.03E-09	2.84E-04	0.
1162.	274.	6.80E-09	7.41E-10	4.22	19.	2.50	0.	305.	139.	5085.	1.24E+02	6.73E-05	3.35E-03-6.06E-09	2.81E-04	0.
1175.	271.	6.78E-09	6.96E-10	4.20	19.	2.50	0.	310.	141.	5056.	1.24E+02	6.66E-05	3.31E-03-6.08E-09	2.78E-04	0.
1187.	269.	6.76E-09	6.53E-10	4.17	19.	2.50	0.	315.	144.	5026.	1.24E+02	6.59E-05	3.28E-03-6.10E-09	2.76E-04	0.
1200.	266.	6.73E-09	6.12E-10	9.25	46.	1.60	0.	0.	146.	7808.	1.78E+02	6.52E-05	7.25E-03-6.12E-09	3.90E-04	0.
1212.	266.	6.70E-09	6.09E-10	9.20	46.	1.60	0.	8.	146.	7803.	1.78E+02	6.51E-05	7.25E-03-6.10E-09	3.90E-04	0.
1225.	265.	6.68E-09	6.05E-10	9.16	46.	1.60	0.	16.	146.	7799.	1.78E+02	6.51E-05	7.24E-03-6.07E-09	3.90E-04	0.
1237.	265.	6.65E-09	6.01E-10	9.11	46.	1.60	0.	24.	147.	7795.	1.78E+02	6.50E-05	7.23E-03-6.04E-09	3.89E-04	0.
1250.	265.	6.62E-09	5.97E-10	9.06	46.	1.60	0.	32.	147.	7790.	1.78E+02	6.49E-05	7.23E-03-6.02E-09	3.89E-04	0.
1262.	265.	6.59E-09	5.94E-10	9.01	46.	1.60	0.	39.	147.	7786.	1.78E+02	6.49E-05	7.22E-03-5.99E-09	3.88E-04	0.
1275.	265.	6.56E-09	5.90E-10	8.97	46.	1.60	0.	47.	147.	7782.	1.78E+02	6.48E-05	7.21E-03-5.97E-09	3.88E-04	0.
1287.	264.	6.53E-09	5.87E-10	8.92	46.	1.60	0.	55.	148.	7777.	1.78E+02	6.47E-05	7.21E-03-5.94E-09	3.88E-04	0.
1300.	264.	6.50E-09	5.83E-10	8.87	46.	1.60	0.	0.	148.	7773.	1.78E+02	6.47E-05	7.20E-03-5.92E-09	3.87E-04	0.
1312.	264.	6.47E-09	5.79E-10	8.83	46.	1.60	0.	8.	148.	7768.	1.78E+02	6.46E-05	7.19E-03-5.89E-09	3.87E-04	0.
1325.	264.	6.44E-09	5.76E-10	8.78	46.	1.60	0.	16.	148.	7764.	1.78E+02	6.45E-05	7.19E-03-5.87E-09	3.87E-04	0.
1337.	263.	6.42E-09	5.72E-10	8.74	46.	1.60	0.	24.	149.	7760.	1.78E+02	6.45E-05	7.18E-03-5.84E-09	3.86E-04	0.
1350.	263.	6.39E-09	5.69E-10	8.69	46.	1.60	0.	32.	149.	7755.	1.78E+02	6.44E-05	7.17E-03-5.82E-09	3.86E-04	0.
1362.	263.	6.36E-09	5.65E-10	8.65	46.	1.60	0.	39.	149.	7751.	1.78E+02	6.43E-05	7.16E-03-5.79E-09	3.86E-04	0.
1375.	262.	6.33E-09	5.62E-10	8.60	46.	1.60	0.	47.	149.	7747.	1.78E+02	6.43E-05	7.16E-03-5.77E-09	3.85E-04	0.
1387.	262.	6.30E-09	5.58E-10	8.56	46.	1.60	0.	55.	149.	7742.	1.78E+02	6.42E-05	7.15E-03-5.75E-09	3.85E-04	0.
1400.	262.	6.28E-09	5.55E-10	8.51	46.	1.60	0.	0.	150.	7738.	1.78E+02	6.41E-05	7.14E-03-5.72E-09	3.85E-04	0.
1412.	262.	6.25E-09	5.51E-10	8.47	46.	1.60	0.	8.	150.	7733.	1.78E+02	6.41E-05	7.14E-03-5.70E-09	3.84E-04	0.
1425.	262.	6.22E-09	5.48E-10	8.43	46.	1.60	0.	16.	150.	7729.	1.78E+02	6.40E-05	7.13E-03-5.67E-09	3.84E-04	0.
1437.	261.	6.19E-09	5.44E-10	8.38	46.	1.60	0.	24.	150.	7725.	1.78E+02	6.39E-05	7.12E-03-5.65E-09	3.84E-04	0.
1450.	261.	6.17E-09	5.41E-10	8.34	46.	1.60	0.	32.	151.	7720.	1.78E+02	6.39E-05	7.12E-03-5.63E-09	3.83E-04	0.
1462.	261.	6.14E-09	5.38E-10	8.30	46.	1.60	0.	39.	151.	7716.	1.78E+02	6.38E-05	7.11E-03-5.60E-09	3.83E-04	0.
1475.	260.	6.11E-09	5.34E-10	8.25	46.	1.60	0.	47.	151.	7712.	1.78E+02	6.37E-05	7.10E-03-5.58E-09	3.82E-04	0.
1487.	260.	6.09E-09	5.31E-10	8.21	46.	1.60	0.	55.	151.	7707.	1.78E+02	6.37E-05	7.10E-03-5.56E-09	3.82E-04	0.
1500.	260.	6.06E-09	5.27E-10	8.17	46.	1.60	0.	0.	152.	7703.	1.78E+02	6.36E-05	7.09E-03-5.53E-09	3.82E-04	0.
1512.	260.	6.03E-09	5.26E-10	8.13	46.	1.60	0.	8.	152.	7701.	1.78E+02	6.36E-05	7.08E-03-5.51E-09	3.82E-04	0.
1525.	260.	6.01E-09	5.24E-10	8.09	46.	1.60	0.	16.	152.	7698.	1.78E+02	6.35E-05	7.08E-03-5.48E-09	3.81E-04	0.
1537.	260.	5.98E-09	5.23E-10	8.05	46.	1.60	0.	24.	152.	7696.	1.78E+02	6.35E-05	7.08E-03-5.46E-09	3.81E-04	0.
1550.	260.	5.96E-09	5.21E-10	8.01	46.	1.60	0.	32.	152.	7694.	1.78E+02	6.35E-05	7.07E-03-5.43E-09	3.81E-04	0.
1562.	259.	5.93E-09	5.19E-10	7.97	46.	1.60	0.	39.	152.	7692.	1.78E+02	6.35E-05	7.07E-03-5.41E-09	3.81E-04	0.
1575.	259.	5.90E-09	5.18E-10	7.93	46.	1.60	0.	47.	152.	7690.	1.78E+02	6.34E-05	7.07E-03-5.39E-09	3.81E-04	0.
1587.	259.	5.88E-09	5.16E-10	7.89	46.	1.60	0.	55.	152.	7688.	1.78E+02	6.34E-05	7.06E-03-5.36E-09	3.81E-04	0.
1600.	259.	5.85E-09	5.14E-10	7.85	46.	1.60	0.	0.	153.	7685.	1.78E+02	6.34E-05	7.06E-03-5.34E-09	3.80E-04	0.
1612.	259.	5.83E-09	5.11E-10	7.81	46.	1.60	0.	8.	153.	7681.	1.78E+02	6.33E-05	7.05E-03-5.32E-09	3.80E-04	0.
1625.	259.	5.80E-09	5.08E-10	7.77	46.	1.60	0.	16.	153.	7677.	1.78E+02	6.32E-05	7.05E-03-5.29E-09	3.80E-04	0.
1637.	258.	5.78E-09	5.05E-10	7.73	46.	1.60	0.	24.	153.	7672.	1.78E+02	6.32E-05	7.04E-03-5.27E-09	3.79E-04	0.
1650.	258.	5.75E-09	5.02E-10	7.69	46.	1.60	0.	32.	153.	7668.	1.78E+02	6.31E-05	7.03E-03-5.25E-09	3.79E-04	0.
1662.	258.	5.73E-09	4.98E-10	7.65	46.	1.60	0.	39.	154.	7663.	1.78E+02	6.30E-05	7.03E-03-5.23E-09	3.79E-04	0.
1675.	257.	5.70E-09	4.95E-10	7.62	46.	1.60	0.	47.	154.	7659.	1.78E+02	6.30E-05	7.02E-03-5.21E-09	3.78E-04	0.
1687.	257.	5.68E-09	4.92E-10	7.58	46.	1.60	0.	55.	154.	7655.	1.78E+02	6.29E-05	7.01E-03-5.19E-09	3.78E-04	0.
1700.	257.	5.65E-09	4.89E-10	7.54	46.	1.60	0.	0.	154.	7650.	1.78E+02	6.28E-05	7.01E-03-5.17E-09	3.78E-04	0.
1712.	257.	5.63E-09	4.87E-10	7.50	46.	1.60	0.	8.	155.	7648.	1.78E+02	6.28E-05	7.00E-03-5.14E-09	3.77E-04	0.
1725.	257.	5.61E-09	4.86E-10	7.46	46.	1.60	0.	16.	155.	7646.	1.78E+02	6.28E-05	7.00E-03-5.12E-09	3.77E-04	0.
1737.	257.	5.58E-09	4.84E-10	7.43	46.	1.60	0.	24.	155.	7644.	1.78E+02	6.27E-05	7.00E-03-5.10E-09	3.77E-04	0.
1750.	257.	5.56E-09	4.83E-10	7.39	46.	1.60	0.	32.	155.	7642.	1.78E+02	6.27E-05	6.99E-03-5.07E-09	3.77E-04	0.

1762.	256.	5.53E-09	4.81E-10	7.36	46.	1.60	0.	39.	155.	7639.	1.78E+02	6.27E-05	6.99E-03	-5.05E-09	3.77E-04	0.
1775.	256.	5.51E-09	4.80E-10	7.32	46.	1.60	0.	47.	155.	7637.	1.78E+02	6.26E-05	6.98E-03	-5.03E-09	3.76E-04	0.
1787.	256.	5.49E-09	4.78E-10	7.28	46.	1.60	0.	55.	155.	7635.	1.78E+02	6.26E-05	6.98E-03	-5.01E-09	3.76E-04	0.
1800.	256.	5.46E-09	4.77E-10	7.25	46.	1.60	0.	0.	155.	7633.	1.78E+02	6.26E-05	6.98E-03	-4.99E-09	3.76E-04	0.
1812.	256.	5.44E-09	4.74E-10	7.21	46.	1.60	0.	8.	156.	7628.	1.78E+02	6.25E-05	6.97E-03	-4.97E-09	3.76E-04	0.
1825.	256.	5.42E-09	4.71E-10	7.18	46.	1.60	0.	16.	156.	7624.	1.78E+02	6.24E-05	6.96E-03	-4.95E-09	3.75E-04	0.
1837.	255.	5.39E-09	4.68E-10	7.14	46.	1.60	0.	24.	156.	7620.	1.78E+02	6.24E-05	6.96E-03	-4.93E-09	3.75E-04	0.
1850.	255.	5.37E-09	4.65E-10	7.10	46.	1.60	0.	32.	156.	7615.	1.79E+02	6.23E-05	6.95E-03	-4.91E-09	3.75E-04	0.
1862.	255.	5.35E-09	4.62E-10	7.07	46.	1.60	0.	39.	157.	7611.	1.79E+02	6.22E-05	6.94E-03	-4.89E-09	3.74E-04	0.
1875.	254.	5.32E-09	4.59E-10	7.03	46.	1.60	0.	47.	157.	7606.	1.79E+02	6.22E-05	6.94E-03	-4.87E-09	3.74E-04	0.
1887.	254.	5.30E-09	4.56E-10	7.00	46.	1.60	0.	55.	157.	7602.	1.79E+02	6.21E-05	6.93E-03	-4.85E-09	3.74E-04	0.
1900.	254.	5.28E-09	4.53E-10	10.18	28.	3.25	2.50	1.	157.	2114.	1.22E+02	6.20E-05	1.01E-02	-4.83E-09	1.96E-03	0.
1912.	257.	5.22E-09	4.84E-10	3.76	28.	3.25	2.50	17.	155.	2127.	4.55E+01	6.27E-05	3.81E-03	-4.74E-09	7.38E-04	0.
1925.	259.	5.18E-09	5.18E-10	3.17	28.	3.25	2.50	34.	152.	2140.	3.86E+01	6.34E-05	3.27E-03	-4.66E-09	6.33E-04	0.
1937.	262.	5.14E-09	5.53E-10	2.94	28.	3.25	2.50	51.	150.	2153.	3.60E+01	6.41E-05	3.07E-03	-4.59E-09	5.95E-04	0.
1950.	265.	5.11E-09	5.90E-10	2.83	28.	3.25	2.50	67.	147.	2165.	3.48E+01	6.48E-05	3.00E-03	-4.52E-09	5.81E-04	0.
1962.	267.	5.08E-09	6.30E-10	2.78	28.	3.25	2.50	84.	145.	2178.	3.43E+01	6.55E-05	3.00E-03	-4.45E-09	5.79E-04	0.
1975.	270.	5.05E-09	6.71E-10	2.75	28.	3.25	2.50	101.	143.	2191.	3.42E+01	6.62E-05	3.02E-03	-4.37E-09	5.84E-04	0.
1987.	272.	5.01E-09	7.15E-10	2.75	28.	3.25	2.50	117.	140.	2204.	3.45E+01	6.69E-05	3.07E-03	-4.30E-09	5.94E-04	0.
2000.	275.	4.98E-09	7.61E-10	2.77	28.	3.25	2.50	133.	138.	2216.	3.49E+01	6.76E-05	3.14E-03	-4.22E-09	6.07E-04	0.
2012.	278.	4.95E-09	8.10E-10	2.78	28.	3.25	2.50	150.	136.	2229.	3.54E+01	6.83E-05	3.22E-03	-4.14E-09	6.22E-04	0.
2025.	280.	4.92E-09	8.62E-10	2.80	28.	3.25	2.50	167.	134.	2242.	3.60E+01	6.91E-05	3.31E-03	-4.06E-09	6.39E-04	0.
2037.	283.	4.89E-09	9.16E-10	2.82	28.	3.25	2.50	183.	132.	2254.	3.66E+01	6.98E-05	3.41E-03	-3.97E-09	6.57E-04	0.
2050.	285.	4.85E-09	9.73E-10	2.84	28.	3.25	2.50	200.	130.	2267.	3.73E+01	7.05E-05	3.51E-03	-3.88E-09	6.76E-04	0.
2062.	288.	4.82E-09	1.03E-09	2.85	28.	3.25	2.50	217.	128.	2280.	3.80E+01	7.12E-05	3.61E-03	-3.79E-09	6.96E-04	0.
2075.	291.	4.79E-09	1.10E-09	2.86	28.	3.25	2.50	233.	126.	2292.	3.88E+01	7.20E-05	3.72E-03	-3.69E-09	7.16E-04	0.
2087.	293.	4.75E-09	1.16E-09	2.87	28.	3.25	2.50	250.	124.	2305.	3.95E+01	7.27E-05	3.83E-03	-3.59E-09	7.37E-04	0.
2100.	296.	4.72E-09	1.23E-09	2.87	28.	3.25	2.50	267.	122.	2318.	4.03E+01	7.34E-05	3.95E-03	-3.49E-09	7.58E-04	0.
2112.	299.	4.69E-09	1.31E-09	2.86	28.	3.25	2.50	283.	120.	2330.	4.10E+01	7.42E-05	4.06E-03	-3.38E-09	7.80E-04	0.
2125.	301.	4.65E-09	1.38E-09	2.85	28.	3.25	2.50	300.	119.	2343.	4.18E+01	7.49E-05	4.18E-03	-3.27E-09	8.01E-04	0.
2137.	304.	4.62E-09	1.46E-09	2.82	28.	3.25	2.50	317.	117.	2356.	4.25E+01	7.57E-05	4.29E-03	-3.16E-09	8.23E-04	0.
2150.	307.	4.59E-09	1.55E-09	2.79	28.	3.25	2.50	333.	115.	2368.	4.33E+01	7.64E-05	4.41E-03	-3.04E-09	8.45E-04	0.
2162.	309.	4.56E-09	1.64E-09	2.75	28.	3.25	2.50	350.	114.	2381.	4.40E+01	7.72E-05	4.52E-03	-2.92E-09	8.67E-04	0.
2175.	312.	4.53E-09	1.73E-09	2.70	28.	3.25	2.50	367.	112.	2393.	4.47E+01	7.79E-05	4.64E-03	-2.80E-09	8.89E-04	0.
2187.	314.	4.50E-09	1.83E-09	2.65	28.	3.25	2.50	383.	110.	2406.	4.53E+01	7.87E-05	4.76E-03	-2.67E-09	9.11E-04	0.
2200.	317.	4.47E-09	1.93E-09	2.58	28.	3.25	2.50	400.	109.	2418.	4.60E+01	7.95E-05	4.87E-03	-2.54E-09	9.32E-04	0.
2212.	320.	4.44E-09	2.03E-09	2.50	28.	3.25	2.50	417.	107.	2431.	4.66E+01	8.02E-05	4.99E-03	-2.40E-09	9.54E-04	0.
2225.	322.	4.41E-09	2.14E-09	2.41	28.	3.25	2.50	433.	106.	2444.	4.72E+01	8.10E-05	5.10E-03	-2.26E-09	9.75E-04	0.
2237.	325.	4.38E-09	2.26E-09	2.30	28.	3.25	2.50	450.	104.	2456.	4.78E+01	8.18E-05	5.21E-03	-2.12E-09	9.96E-04	0.
2250.	328.	4.36E-09	2.38E-09	2.19	28.	3.25	2.50	467.	103.	2469.	4.84E+01	8.25E-05	5.33E-03	-1.97E-09	1.02E-03	0.
2262.	330.	4.33E-09	2.51E-09	2.07	28.	3.25	2.50	483.	101.	2481.	4.90E+01	8.33E-05	5.44E-03	-1.82E-09	1.04E-03	0.
2275.	333.	4.31E-09	2.64E-09	1.93	28.	3.25	2.50	500.	100.	2494.	4.95E+01	8.41E-05	5.55E-03	-1.67E-09	1.06E-03	0.
2287.	335.	4.29E-09	2.78E-09	1.78	28.	3.25	2.50	517.	99.	2506.	5.00E+01	8.49E-05	5.66E-03	-1.51E-09	1.08E-03	0.
2300.	338.	4.27E-09	2.92E-09	1.62	28.	3.25	2.50	533.	97.	2518.	5.05E+01	8.57E-05	5.77E-03	-1.35E-09	1.10E-03	0.
2312.	340.	4.25E-09	3.06E-09	1.45	28.	3.25	2.50	550.	96.	2530.	5.10E+01	8.64E-05	5.87E-03	-1.19E-09	1.12E-03	0.
2325.	343.	4.23E-09	3.21E-09	1.27	28.	3.25	2.50	567.	95.	2542.	5.14E+01	8.72E-05	5.97E-03	-1.02E-09	1.14E-03	0.
2337.	346.	4.22E-09	3.37E-09	1.08	28.	3.25	2.50	583.	94.	2554.	5.18E+01	8.80E-05	6.08E-03	-8.54E-10	1.16E-03	0.
2350.	348.	4.21E-09	3.53E-09	0.88	28.	3.25	2.50	600.	92.	2566.	5.22E+01	8.87E-05	6.18E-03	-6.83E-10	1.17E-03	0.
2362.	351.	4.20E-09	3.69E-09	0.66	28.	3.25	2.50	617.	91.	2578.	5.26E+01	8.95E-05	6.27E-03	-5.08E-10	1.19E-03	0.
2375.	353.	4.19E-09	3.87E-09	0.44	28.	3.25	2.50	633.	90.	2589.	5.30E+01	9.03E-05	6.37E-03	-3.28E-10	1.21E-03	0.
2387.	356.	4.19E-09	4.05E-09	0.20	28.	3.25	2.50	650.	89.	2601.	5.33E+01	9.10E-05	6.47E-03	-1.45E-10	1.23E-03	0.
2400.	358.	4.19E-09	4.23E-09	1.12	28.	3.25	2.50	667.	88.	2613.	5.36E+01	9.10E-05	6.57E-03	-8.20E-10	1.25E-03	0.
2412.	361.	4.18E-09	4.44E-09	0.90	28.	3.25	2.50	683.	87.	2625.	5.40E+01	9.26E-05	6.67E-03	-6.40E-10	1.26E-03	0.
2425.	363.	4.17E-09	4.65E-09	0.66	28.	3.25	2.50	700.	86.	2638.	5.43E+01	9.35E-05	6.77E-03	-4.71E-10	1.28E-03	0.
2437.	366.	4.16E-09	4.87E-09	0.42	28.	3.25	2.50	717.	84.	2650.	5.46E+01	9.43E-05	6.87E-03	-2.90E-10	1.30E-03	0.
2450.	368.	4.16E-09	5.09E-09	0.15	28.	3.25	2.50	733.	83.	2662.	5.49E+01	9.51E-05	6.96E-03	-1.06E-10	1.32E-03	0.
2462.	371.	4.16E-09	5.33E-09	-0.12	28.	3.25	2.50	750.	82.	2675.	5.52E+01	9.59E-05	7.06E-03	8.25E-11	1.34E-03	0.
2475.	374.	4.16E-09	5.58E-09	-0.41	28.	3.25	2.50	767.	81.	2687.	5.55E+01	9.68E-05	7.16E-03	2.75E-10	1.35E-03	0.
2487.	376.	4.17E-09	5.83E-09	-0.71	28.	3.25	2.50	783.	80.	2699.	5.57E+01	9.76E-05	7.25E-03	4.71E-10	1.37E-03	0.
2500.	379.	4.18E-09	6.10E-09	-1.03	28.	3.25	2.50	800.	79.	2712.	5.60E+01	9.85E-05	7.35E-03	6.71E-10	1.39E-03	0.

2512.	382.	4.19E-09	6.37E-09	-1.36	28.	3.25	2.50	817.	78.	2724.	5.62E+01	9.93E-05	7.44E-03	8.76E-10	1.41E-03	0.
2525.	384.	4.21E-09	6.65E-09	-1.70	28.	3.25	2.50	833.	77.	2736.	5.64E+01	1.00E-04	7.53E-03	1.00E-09	1.42E-03	0.
2537.	387.	4.23E-09	6.95E-09	-2.06	28.	3.25	2.50	850.	76.	2748.	5.66E+01	1.01E-04	7.62E-03	1.30E-09	1.44E-03	0.
2550.	390.	4.25E-09	7.25E-09	-2.43	28.	3.25	2.50	867.	75.	2761.	5.68E+01	1.02E-04	7.72E-03	1.51E-09	1.46E-03	0.
2562.	392.	4.28E-09	7.57E-09	-2.82	28.	3.25	2.50	883.	75.	2773.	5.70E+01	1.03E-04	7.81E-03	1.73E-09	1.47E-03	0.
2575.	395.	4.32E-09	7.89E-09	-3.23	28.	3.25	2.50	900.	74.	2785.	5.72E+01	1.04E-04	7.90E-03	1.96E-09	1.49E-03	0.
2587.	397.	4.36E-09	8.23E-09	-3.64	28.	3.25	2.50	917.	73.	2797.	5.74E+01	1.04E-04	7.99E-03	2.19E-09	1.50E-03	0.
2600.	400.	4.40E-09	8.58E-09	-4.08	28.	3.25	2.50	933.	72.	2810.	5.75E+01	1.05E-04	8.08E-03	2.42E-09	1.52E-03	0.
2612.	403.	4.45E-09	8.94E-09	-4.53	28.	3.25	2.50	950.	71.	2822.	5.77E+01	1.06E-04	8.16E-03	2.66E-09	1.54E-03	0.
2625.	405.	4.50E-09	9.32E-09	-5.00	28.	3.25	2.50	967.	70.	2834.	5.78E+01	1.07E-04	8.25E-03	2.91E-09	1.55E-03	0.
2637.	408.	4.56E-09	9.70E-09	-5.48	28.	3.25	2.50	983.	69.	2846.	5.80E+01	1.08E-04	8.34E-03	3.16E-09	1.57E-03	0.
2650.	410.	4.63E-09	1.01E-08	-5.98	28.	3.25	2.50	1000.	69.	2858.	5.81E+01	1.09E-04	8.43E-03	3.41E-09	1.58E-03	0.
2662.	413.	4.70E-09	1.05E-08	-6.50	28.	3.25	2.50	1017.	68.	2870.	5.82E+01	1.10E-04	8.51E-03	3.67E-09	1.60E-03	0.
2675.	416.	4.77E-09	1.09E-08	-7.04	28.	3.25	2.50	1033.	67.	2883.	5.83E+01	1.11E-04	8.60E-03	3.93E-09	1.61E-03	0.
2687.	418.	4.86E-09	1.14E-08	-7.59	28.	3.25	2.50	1050.	66.	2895.	5.84E+01	1.11E-04	8.68E-03	4.20E-09	1.63E-03	0.
2700.	421.	4.94E-09	1.18E-08	-11.23	40.	1.60	0.	0.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.47E-09	6.29E-04	0.
2712.	421.	4.98E-09	1.18E-08	-11.15	40.	1.60	0.	8.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.43E-09	6.29E-04	0.
2725.	421.	5.01E-09	1.18E-08	-11.06	40.	1.60	0.	16.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.40E-09	6.29E-04	0.
2737.	421.	5.05E-09	1.18E-08	-10.97	40.	1.60	0.	24.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.37E-09	6.29E-04	0.
2750.	421.	5.08E-09	1.18E-08	-10.89	40.	1.60	0.	32.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.33E-09	6.29E-04	0.
2762.	421.	5.12E-09	1.18E-08	-10.80	40.	1.60	0.	39.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.30E-09	6.29E-04	0.
2775.	421.	5.15E-09	1.18E-08	-10.72	40.	1.60	0.	47.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.26E-09	6.29E-04	0.
2787.	421.	5.18E-09	1.18E-08	-10.63	40.	1.60	0.	55.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.23E-09	6.29E-04	0.
2800.	421.	5.22E-09	1.18E-08	-10.55	40.	1.60	0.	0.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.20E-09	6.29E-04	0.
2812.	421.	5.25E-09	1.18E-08	-10.47	40.	1.60	0.	8.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.16E-09	6.29E-04	0.
2825.	421.	5.28E-09	1.18E-08	-10.39	40.	1.60	0.	16.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.13E-09	6.29E-04	0.
2837.	421.	5.31E-09	1.18E-08	-10.30	40.	1.60	0.	24.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.10E-09	6.29E-04	0.
2850.	421.	5.35E-09	1.18E-08	-10.22	40.	1.60	0.	32.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.07E-09	6.29E-04	0.
2862.	421.	5.38E-09	1.18E-08	-10.14	40.	1.60	0.	39.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.04E-09	6.29E-04	0.
2875.	421.	5.41E-09	1.18E-08	-10.06	40.	1.60	0.	47.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	4.00E-09	6.29E-04	0.
2887.	421.	5.44E-09	1.18E-08	-9.99	40.	1.60	0.	55.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	3.97E-09	6.29E-04	0.
2900.	421.	5.47E-09	1.18E-08	-9.91	40.	1.60	0.	0.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	3.94E-09	6.29E-04	0.
2912.	421.	5.50E-09	1.18E-08	-9.83	40.	1.60	0.	8.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	3.91E-09	6.29E-04	0.
2925.	421.	5.53E-09	1.18E-08	-9.75	40.	1.60	0.	16.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	3.88E-09	6.29E-04	0.
2937.	421.	5.56E-09	1.18E-08	-9.68	40.	1.60	0.	24.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	3.85E-09	6.29E-04	0.
2950.	421.	5.59E-09	1.18E-08	-9.60	40.	1.60	0.	32.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	3.82E-09	6.29E-04	0.
2957.	421.	5.61E-09	1.18E-08	-9.56	40.	1.60	0.	36.	65.	10446.	1.72E+02	1.12E-04	1.21E-02	3.80E-09	6.29E-04	0.

FOLLOWING TABLE SHOWS AXIAL DISTANCE X (CM),
TEMP T (C), CONCENTRATION AND SOLUBILITY C AND S (GMOL/CM3),
WALL FLUX N (NEG IS LOSS MG/CM2/MONTH), VEL V (CM/S).
DIAM D (CM), ANNULUS I.D. OR PLATE WIDTH W (CM), L/D,
SCHMIDT,REYNOLDS,NUSSELT NUMBERS, DIFFUSIVITY,MTC CGS,DELTA C, 4K/DV

X	TEMP	CONCENTN	SOLUBILTY	FLUX	VEL	DIAM	W	L/D	SCHM	REYNLD	NUSSELT	DFFUSVTY	MTC(CGS)	DELTA C	4K/DV	
12.	481.	1.35E-08	2.69E-08	-3.68	3.	6.00	0.	2.	51.	3050.	5.91E+01	1.34E-04	1.32E-03	1.34E-08	2.54E-04	0.
25.	482.	1.36E-08	2.74E-08	-3.79	3.	6.00	0.	4.	51.	3055.	5.89E+01	1.34E-04	1.32E-03	1.38E-08	2.54E-04	0.
37.	484.	1.36E-08	2.78E-08	-3.90	3.	6.00	0.	6.	50.	3060.	5.88E+01	1.35E-04	1.32E-03	1.42E-08	2.54E-04	0.
50.	485.	1.36E-08	2.82E-08	-4.01	3.	6.00	0.	8.	50.	3066.	5.87E+01	1.35E-04	1.32E-03	1.46E-08	2.55E-04	0.
62.	486.	1.37E-08	2.87E-08	-4.13	3.	6.00	0.	10.	50.	3071.	5.86E+01	1.35E-04	1.32E-03	1.50E-08	2.55E-04	0.
75.	487.	1.37E-08	2.91E-08	-4.25	3.	6.00	0.	13.	50.	3077.	5.85E+01	1.36E-04	1.33E-03	1.54E-08	2.56E-04	0.
87.	489.	1.38E-08	2.96E-08	-4.37	3.	6.00	0.	15.	49.	3082.	5.85E+01	1.36E-04	1.33E-03	1.58E-08	2.56E-04	0.
100.	490.	1.38E-08	3.00E-08	-4.50	3.	6.00	0.	17.	49.	3087.	5.85E+01	1.37E-04	1.33E-03	1.62E-08	2.57E-04	0.
113.	491.	1.39E-08	3.05E-08	-4.62	3.	6.00	0.	19.	49.	3093.	5.84E+01	1.37E-04	1.34E-03	1.66E-08	2.58E-04	0.
125.	493.	1.40E-08	3.10E-08	-4.75	3.	6.00	0.	21.	49.	3098.	5.84E+01	1.38E-04	1.34E-03	1.70E-08	2.58E-04	0.
138.	494.	1.40E-08	3.14E-08	-4.88	3.	6.00	0.	23.	48.	3104.	5.84E+01	1.38E-04	1.34E-03	1.74E-08	2.59E-04	0.
150.	495.	1.41E-08	3.19E-08	-5.02	3.	6.00	0.	25.	48.	3109.	5.83E+01	1.39E-04	1.35E-03	1.79E-08	2.60E-04	0.
163.	496.	1.41E-08	3.24E-08	-5.15	3.	6.00	0.	27.	48.	3114.	5.83E+01	1.39E-04	1.35E-03	1.83E-08	2.60E-04	0.
175.	497.	1.42E-08	3.29E-08	-5.29	3.	6.00	0.	29.	48.	3120.	5.83E+01	1.40E-04	1.36E-03	1.87E-08	2.61E-04	0.
188.	499.	1.42E-08	3.34E-08	-5.43	3.	6.00	0.	31.	47.	3125.	5.83E+01	1.40E-04	1.36E-03	1.91E-08	2.62E-04	0.
200.	500.	1.43E-08	3.39E-08	-53.26	60.	1.35	0.	0.	47.	13914.	1.94E+02	1.41E-04	2.02E-02	1.27E-08	8.74E-04	0.

212.	499.	1.45E-08	3.35E-08	-24.43	27.	1.35	0.	10.	47.	5530.	[illegible]	1.40E-04	[illegible]	[illegible]	[illegible]	0.
225.	498.	1.46E-08	3.31E-08	-23.44	27.	1.35	0.	19.	48.	5522.	9.29E+01	1.40E-04	9.62E-03	1.17E-08	1.05E-03	0.
237.	497.	1.48E-08	3.27E-08	-22.45	27.	1.35	0.	28.	48.	5515.	9.29E+01	1.39E-04	9.60E-03	1.12E-08	1.04E-03	0.
250.	496.	1.49E-08	3.23E-08	-21.48	27.	1.35	0.	37.	48.	5507.	9.29E+01	1.39E-04	9.57E-03	1.08E-08	1.04E-03	0.
262.	495.	1.51E-08	3.19E-08	-20.54	27.	1.35	0.	47.	48.	5500.	9.29E+01	1.39E-04	9.55E-03	1.03E-08	1.04E-03	0.
275.	494.	1.52E-08	3.15E-08	-19.62	27.	1.35	0.	56.	48.	5492.	9.29E+01	1.38E-04	9.52E-03	9.89E-09	1.04E-03	0.
288.	493.	1.53E-08	3.11E-08	-18.73	27.	1.35	0.	65.	49.	5484.	9.29E+01	1.38E-04	9.50E-03	9.46E-09	1.03E-03	0.
300.	492.	1.54E-08	3.08E-08	-73.20	131.	0.62	0.	1.	49.	12002.	1.74E+02	1.38E-04	3.89E-02	9.04E-09	1.93E-03	0.
305.	492.	1.55E-08	3.08E-08	-26.94	131.	0.62	0.	1.	49.	12002.						
310.	492.	1.55E-08	3.08E-08	-19.01	131.	0.62	0.	1.	49.	12002.						
315.	492.	1.55E-08	3.08E-08	-15.50	131.	0.62	0.	1.	49.	12002.						
320.	492.	1.55E-08	3.08E-08	-13.41	131.	0.62	0.	1.	49.	12002.						

LENGTH REYNOLDS NUMBER=450000. AT 20.CM(32.DIAMS) INTO STRINGER #1

332.	492.	1.57E-08	3.08E-08	-70.81	131.	0.62	0.	54.	49.	12002.	1.74E+02	1.38E-04	3.89E-02	8.74E-09	1.93E-03	0.
345.	492.	1.59E-08	3.08E-08	-69.11	131.	0.62	0.	74.	49.	12002.	1.74E+02	1.38E-04	3.89E-02	8.53E-09	1.93E-03	0.
357.	492.	1.62E-08	3.08E-08	-67.46	131.	0.62	0.	94.	49.	12002.	1.74E+02	1.38E-04	3.89E-02	8.32E-09	1.93E-03	0.
370.	492.	1.64E-08	3.08E-08	-65.85	131.	0.62	0.	114.	49.	12002.	1.74E+02	1.38E-04	3.89E-02	8.13E-09	1.93E-03	0.
382.	492.	1.65E-08	3.08E-08	-64.28	131.	0.62	0.	135.	49.	12002.	1.74E+02	1.38E-04	3.89E-02	7.93E-09	1.93E-03	0.
395.	492.	1.67E-08	3.08E-08	-62.75	131.	0.62	0.	155.	49.	12002.	1.74E+02	1.38E-04	3.89E-02	7.74E-09	1.93E-03	0.
400.	492.	1.68E-08	3.08E-08	-5.10	8.	2.50	0.	0.	49.	2957.	5.80E+01	1.38E-04	3.19E-03	7.67E-09	6.44E-04	0.
212.	499.	1.45E-08	3.35E-08	-13.18	13.	1.35	0.	10.	47.	2640.	5.02E+01	1.40E-04	5.21E-03	1.21E-08	1.19E-03	0.
225.	498.	1.47E-08	3.31E-08	-12.38	13.	1.35	0.	19.	48.	2636.	4.92E+01	1.40E-04	5.10E-03	1.17E-08	1.16E-03	0.
237.	497.	1.48E-08	3.27E-08	-11.70	13.	1.35	0.	28.	48.	2633.	4.87E+01	1.39E-04	5.03E-03	1.12E-08	1.15E-03	0.
250.	496.	1.50E-08	3.23E-08	-11.09	13.	1.35	0.	37.	48.	2629.	4.83E+01	1.39E-04	4.97E-03	1.07E-08	1.13E-03	0.
262.	495.	1.51E-08	3.19E-08	-10.51	13.	1.35	0.	47.	48.	2625.	4.79E+01	1.39E-04	4.92E-03	1.02E-08	1.12E-03	0.
275.	494.	1.53E-08	3.15E-08	-9.97	13.	1.35	0.	56.	48.	2622.	4.76E+01	1.38E-04	4.88E-03	9.80E-09	1.11E-03	0.
288.	493.	1.54E-08	3.11E-08	-9.44	13.	1.35	0.	65.	49.	2618.	4.74E+01	1.38E-04	4.84E-03	9.36E-09	1.10E-03	0.
300.	492.	1.55E-08	3.08E-08	-40.09	62.	0.62	0.	1.	49.	5730.	9.64E+01	1.38E-04	2.15E-02	8.94E-09	2.24E-03	0.
305.	492.	1.56E-08	3.08E-08	-18.49	62.	0.62	0.	1.	49.	5730.						
310.	492.	1.56E-08	3.08E-08	-13.03	62.	0.62	0.	1.	49.	5730.						
315.	492.	1.56E-08	3.08E-08	-10.62	62.	0.62	0.	1.	49.	5730.						
320.	492.	1.57E-08	3.08E-08	-9.18	62.	0.62	0.	1.	49.	5730.						
325.	492.	1.57E-08	3.08E-08	-8.20	62.	0.62	0.	1.	49.	5730.						
330.	492.	1.57E-08	3.08E-08	-7.47	62.	0.62	0.	1.	49.	5730.						
335.	492.	1.57E-08	3.08E-08	-6.91	62.	0.62	0.	1.	49.	5730.						
340.	492.	1.57E-08	3.08E-08	-6.46	62.	0.62	0.	1.	49.	5730.						
345.	492.	1.58E-08	3.08E-08	-6.08	62.	0.62	0.	1.	49.	5730.						

LENGTH REYNOLDS NUMBER=450000. AT 45.CM(73.DIAMS) INTO STRINGER #2

357.	492.	1.60E-08	3.08E-08	-38.03	62.	0.62	0.	94.	49.	5730.	9.64E+01	1.38E-04	2.15E-02	8.48E-09	2.24E-03	0.
370.	492.	1.62E-08	3.08E-08	-36.98	62.	0.62	0.	114.	49.	5730.	9.64E+01	1.38E-04	2.15E-02	8.24E-09	2.24E-03	0.
382.	492.	1.65E-08	3.08E-08	-35.95	62.	0.62	0.	135.	49.	5730.	9.64E+01	1.38E-04	2.15E-02	8.02E-09	2.24E-03	0.
395.	492.	1.67E-08	3.08E-08	-34.96	62.	0.62	0.	155.	49.	5730.	9.64E+01	1.38E-04	2.15E-02	7.79E-09	2.24E-03	0.
400.	492.	1.68E-08	3.08E-08	-9.61	4.	2.50	0.	0.	49.	1412.	1.09E+02	1.38E-04	5.99E-03	7.71E-09	2.53E-03	0.
212.	499.	1.45E-08	3.35E-08	-8.55	9.	1.35	0.	10.	47.	1820.	3.26E+01	1.40E-04	3.39E-03	1.21E-08	1.12E-03	0.
225.	498.	1.47E-08	3.31E-08	-6.56	9.	1.35	0.	19.	48.	1818.	2.62E+01	1.40E-04	2.71E-03	1.16E-08	8.96E-04	0.
237.	497.	1.48E-08	3.27E-08	-5.53	9.	1.35	0.	28.	48.	1815.	2.30E+01	1.39E-04	2.37E-03	1.12E-08	7.84E-04	0.
250.	496.	1.49E-08	3.23E-08	-4.84	9.	1.35	0.	37.	48.	1813.	2.09E+01	1.39E-04	2.16E-03	1.08E-08	7.13E-04	0.
262.	495.	1.50E-08	3.19E-08	-4.32	9.	1.35	0.	47.	48.	1810.	1.95E+01	1.39E-04	2.00E-03	1.04E-08	6.61E-04	0.
275.	494.	1.51E-08	3.15E-08	-3.91	9.	1.35	0.	56.	48.	1808.	1.83E+01	1.38E-04	1.88E-03	9.99E-09	6.22E-04	0.
288.	493.	1.52E-08	3.11E-08	-3.57	9.	1.35	0.	65.	49.	1805.	1.75E+01	1.38E-04	1.78E-03	9.61E-09	5.90E-04	0.
300.	492.	1.52E-08	3.08E-08	-30.81	43.	0.62	0.	1.	49.	3950.	7.16E+01	1.38E-04	1.60E-02	9.25E-09	2.42E-03	0.
305.	492.	1.53E-08	3.08E-08	-15.66	43.	0.62	0.	1.	49.	3950.						
310.	492.	1.53E-08	3.08E-08	-11.03	43.	0.62	0.	1.	49.	3950.						
315.	492.	1.54E-08	3.08E-08	-8.90	43.	0.62	0.	1.	49.	3950.						
320.	492.	1.54E-08	3.08E-08	-7.76	43.	0.62	0.	1.	49.	3950.						
325.	492.	1.54E-08	3.08E-08	-6.93	43.	0.62	0.	1.	49.	3950.						
330.	492.	1.54E-08	3.08E-08	-6.32	43.	0.62	0.	1.	49.	3950.						
335.	492.	1.55E-08	3.08E-08	-5.84	43.	0.62	0.	1.	49.	3950.						
340.	492.	1.55E-08	3.08E-08	-5.46	43.	0.62	0.	1.	49.	3950.						
345.	492.	1.55E-08	3.08E-08	-5.14	43.	0.62	0.	1.	49.	3950.						

350.	492.	1.55E-08	3.08E-08	-4.87	43.	0.62	0.	1.	49.	3950.
355.	492.	1.55E-08	3.08E-08	-4.64	43.	0.62	0.	1.	49.	3950.
360.	492.	1.56E-08	3.08E-08	-4.43	43.	0.62	0.	1.	49.	3950.
365.	492.	1.56E-08	3.08E-08	-4.26	43.	0.62	0.	1.	49.	3950.
370.	492.	1.56E-08	3.08E-08	-4.10	43.	0.62	0.	1.	49.	3950.

LENGTH REYNOLDS NUMBER=450000. AT 70.CM(114.DIAMS) INTO STRINGER #3

382.	492.	1.58E-08	3.08E-08	-28.71	43.	0.62	0.	135.	49.	3950.	7.15E+01	1.38E-04	1.60E-02	8.63E-09	2.41E-03	0.
395.	492.	1.61E-08	3.08E-08	-27.86	43.	0.62	0.	155.	49.	3950.	7.15E+01	1.38E-04	1.60E-02	8.37E-09	2.41E-03	0.
400.	492.	1.62E-08	3.08E-08	-9.13	3.	2.50	0.	0.	49.	973.	9.62E+01	1.38E-04	5.30E-03	8.27E-09	3.25E-03	0.
212.	499.	1.45E-08	3.35E-08	-18.48	19.	1.35	0.	10.	47.	3904.	7.02E+01	1.40E-04	7.30E-03	1.22E-08	1.12E-03	0.
225.	498.	1.47E-08	3.31E-08	-17.69	19.	1.35	0.	19.	48.	3899.	7.02E+01	1.40E-04	7.28E-03	1.17E-08	1.12E-03	0.
237.	497.	1.48E-08	3.27E-08	-16.93	19.	1.35	0.	28.	48.	3894.	7.02E+01	1.39E-04	7.26E-03	1.12E-08	1.12E-03	0.
250.	496.	1.50E-08	3.23E-08	-16.18	19.	1.35	0.	37.	48.	3888.	7.02E+01	1.39E-04	7.24E-03	1.07E-08	1.12E-03	0.
262.	495.	1.51E-08	3.19E-08	-15.45	19.	1.35	0.	47.	48.	3883.	7.02E+01	1.39E-04	7.22E-03	1.03E-08	1.11E-03	0.
275.	494.	1.53E-08	3.15E-08	-14.75	19.	1.35	0.	56.	48.	3877.	7.03E+01	1.38E-04	7.20E-03	9.83E-09	1.11E-03	0.
288.	493.	1.54E-08	3.11E-08	-14.05	19.	1.35	0.	65.	49.	3872.	7.03E+01	1.38E-04	7.18E-03	9.39E-09	1.11E-03	0.
300.	492.	1.55E-08	3.08E-08	-55.81	92.	0.62	0.	1.	49.	8474.	1.32E+02	1.38E-04	2.94E-02	8.97E-09	2.07E-03	0.
305.	492.	1.56E-08	3.08E-08	-22.53	92.	0.62	0.	1.	49.	8474.						
310.	492.	1.56E-08	3.08E-08	-15.89	92.	0.62	0.	1.	49.	8474.						
315.	492.	1.56E-08	3.08E-08	-12.95	92.	0.62	0.	1.	49.	8474.						
320.	492.	1.56E-08	3.08E-08	-11.20	92.	0.62	0.	1.	49.	8474.						
325.	492.	1.56E-08	3.08E-08	-10.00	92.	0.62	0.	1.	49.	8474.						
330.	492.	1.57E-08	3.08E-08	-9.12	92.	0.62	0.	1.	49.	8474.						

LENGTH REYNOLDS NUMBER=450000. AT 30.CM(49.DIAMS) INTO STRINGER #4

343.	492.	1.59E-08	3.08E-08	-52.76	92.	0.62	0.	70.	49.	8474.	1.32E+02	1.38E-04	2.94E-02	8.60E-09	2.07E-03	0.
355.	492.	1.61E-08	3.08E-08	-51.41	92.	0.62	0.	90.	49.	8474.	1.32E+02	1.38E-04	2.94E-02	8.38E-09	2.07E-03	0.
360.	492.	1.63E-08	3.08E-08	-50.09	92.	0.62	0.	110.	49.	8474.	1.32E+02	1.38E-04	2.94E-02	8.17E-09	2.07E-03	0.
380.	492.	1.65E-08	3.08E-08	-48.81	92.	0.62	0.	131.	49.	8474.	1.32E+02	1.38E-04	2.94E-02	7.96E-09	2.07E-03	0.
393.	492.	1.67E-08	3.08E-08	-47.56	92.	0.62	0.	151.	49.	8474.	1.32E+02	1.38E-04	2.94E-02	7.75E-09	2.07E-03	0.
400.	492.	1.68E-08	3.08E-08	-10.84	6.	2.50	0.	0.	49.	2088.	1.24E+02	1.38E-04	6.81E-03	7.63E-09	1.95E-03	0.
412.	490.	1.68E-08	2.98E-08	-9.41	20.	2.50	0.	5.	49.	7405.	1.19E+02	1.37E-04	6.49E-03	6.96E-09	5.21E-04	0.
425.	487.	1.68E-08	2.89E-08	-8.32	20.	2.50	0.	10.	50.	7379.	1.19E+02	1.36E-04	6.45E-03	6.20E-09	5.18E-04	0.
437.	484.	1.69E-08	2.81E-08	-7.28	20.	2.50	0.	15.	50.	7353.	1.19E+02	1.35E-04	6.41E-03	5.45E-09	5.15E-04	0.
450.	482.	1.69E-08	2.72E-08	-6.28	20.	2.50	0.	20.	51.	7327.	1.19E+02	1.34E-04	6.37E-03	4.74E-09	5.12E-04	0.
462.	480.	1.69E-08	2.63E-08	-5.32	20.	2.50	0.	25.	51.	7301.	1.19E+02	1.33E-04	6.33E-03	4.04E-09	5.09E-04	0.
475.	477.	1.69E-08	2.55E-08	-4.40	20.	2.50	0.	30.	52.	7275.	1.19E+02	1.32E-04	6.29E-03	3.36E-09	5.06E-04	0.
487.	475.	1.70E-08	2.47E-08	-3.52	20.	2.50	0.	35.	52.	7249.	1.19E+02	1.31E-04	6.25E-03	2.71E-09	5.03E-04	0.
500.	472.	1.70E-08	2.39E-08	-2.68	20.	2.50	0.	40.	53.	7222.	1.19E+02	1.30E-04	6.21E-03	2.07E-09	5.00E-04	0.
512.	470.	1.70E-08	2.32E-08	-1.91	20.	2.50	0.	45.	53.	7190.	1.19E+02	1.29E-04	6.17E-03	1.48E-09	4.97E-04	0.
525.	467.	1.70E-08	2.25E-08	-1.17	20.	2.50	0.	50.	54.	7173.	1.19E+02	1.29E-04	6.13E-03	9.14E-10	4.95E-04	0.
537.	465.	1.70E-08	2.18E-08	-0.46	20.	2.50	0.	55.	54.	7148.	1.19E+02	1.28E-04	6.09E-03	3.62E-10	4.92E-04	0.
550.	462.	1.70E-08	2.12E-08	0.22	20.	2.50	0.	60.	55.	7123.	1.19E+02	1.27E-04	6.05E-03	-1.73E-10	4.89E-04	0.
562.	460.	1.70E-08	2.05E-08	0.87	20.	2.50	0.	65.	55.	7098.	1.19E+02	1.26E-04	6.02E-03	-6.92E-10	4.86E-04	0.
575.	458.	1.70E-08	1.99E-08	1.49	20.	2.50	0.	70.	56.	7073.	1.19E+02	1.25E-04	5.98E-03	-1.19E-09	4.83E-04	0.
587.	455.	1.70E-08	1.92E-08	2.08	20.	2.50	0.	75.	56.	7048.	1.19E+02	1.24E-04	5.94E-03	-1.68E-09	4.80E-04	0.
600.	453.	1.70E-08	1.86E-08	2.65	20.	2.50	0.	80.	57.	7024.	1.20E+02	1.23E-04	5.90E-03	-2.15E-09	4.78E-04	0.
612.	450.	1.70E-08	1.80E-08	3.22	20.	2.50	0.	85.	58.	6997.	1.20E+02	1.23E-04	5.86E-03	-2.64E-09	4.75E-04	0.
625.	448.	1.69E-08	1.74E-08	3.76	20.	2.50	0.	90.	58.	6971.	1.20E+02	1.22E-04	5.82E-03	-3.10E-09	4.72E-04	0.
637.	446.	1.69E-08	1.68E-08	0.14	20.	2.50	0.	95.	59.	6945.	1.20E+02	1.21E-04	5.78E-03	-1.17E-10	4.69E-04	0.
650.	443.	1.69E-08	1.62E-08	0.82	20.	2.50	0.	100.	59.	6918.	1.20E+02	1.20E-04	5.74E-03	-6.86E-10	4.66E-04	0.
662.	440.	1.69E-08	1.57E-08	1.47	20.	2.50	0.	105.	60.	6892.	1.20E+02	1.19E-04	5.71E-03	-1.24E-09	4.63E-04	0.
675.	438.	1.69E-08	1.51E-08	2.09	20.	2.50	0.	110.	61.	6866.	1.20E+02	1.18E-04	5.67E-03	-1.77E-09	4.60E-04	0.
687.	435.	1.69E-08	1.46E-08	2.68	20.	2.50	0.	115.	61.	6839.	1.20E+02	1.17E-04	5.63E-03	-2.29E-09	4.57E-04	0.
700.	433.	1.69E-08	1.41E-08	3.24	20.	2.50	0.	120.	62.	6813.	1.20E+02	1.16E-04	5.59E-03	-2.79E-09	4.54E-04	0.
712.	431.	1.69E-08	1.36E-08	3.75	20.	2.50	0.	125.	63.	6788.	1.20E+02	1.16E-04	5.55E-03	-3.24E-09	4.51E-04	0.
725.	428.	1.68E-08	1.32E-08	4.23	20.	2.50	0.	130.	63.	6763.	1.20E+02	1.15E-04	5.52E-03	-3.68E-09	4.49E-04	0.
737.	426.	1.68E-08	1.27E-08	4.69	20.	2.50	0.	135.	64.	6737.	1.20E+02	1.14E-04	5.48E-03	-4.11E-09	4.46E-04	0.
750.	424.	1.68E-08	1.23E-08	5.13	20.	2.50	0.	140.	65.	6712.	1.20E+02	1.13E-04	5.44E-03	-4.52E-09	4.43E-04	0.
762.	421.	1.68E-08	1.19E-08	5.54	20.	2.50	0.	145.	65.	6687.	1.20E+02	1.12E-04	5.41E-03	-4.92E-09	4.40E-04	0.
775.	419.	1.67E-08	1.14E-08	5.93	20.	2.50	0.	150.	66.	6662.	1.20E+02	1.12E-04	5.37E-03	-5.30E-09	4.38E-04	0.

787.	416.	1.67E-08	1.10E-08	6.30	20.	2.50	0.	155.	67.	6637.	1.20E+02	1.11E-04	5.33E-03	-5.67E-09	4.35E-04	0.
800.	414.	1.67E-08	1.07E-08	6.66	20.	2.50	0.	160.	67.	6611.	1.20E+02	1.10E-04	5.30E-03	-6.03E-09	4.32E-04	0.
812.	412.	1.67E-08	1.03E-08	7.01	20.	2.50	0.	165.	68.	6585.	1.21E+02	1.09E-04	5.26E-03	-6.39E-09	4.29E-04	0.
825.	409.	1.66E-08	9.87E-09	7.34	20.	2.50	0.	170.	69.	6558.	1.21E+02	1.08E-04	5.22E-03	-6.74E-09	4.26E-04	0.
837.	406.	1.66E-08	9.50E-09	7.65	20.	2.50	0.	175.	70.	6531.	1.21E+02	1.07E-04	5.18E-03	-7.08E-09	4.24E-04	0.
850.	404.	1.65E-08	9.14E-09	7.94	20.	2.50	0.	180.	71.	6505.	1.21E+02	1.07E-04	5.15E-03	-7.40E-09	4.21E-04	0.
862.	402.	1.65E-08	8.79E-09	8.21	20.	2.50	0.	185.	71.	6478.	1.21E+02	1.06E-04	5.11E-03	-7.72E-09	4.18E-04	0.
875.	399.	1.65E-08	8.45E-09	8.47	20.	2.50	0.	190.	72.	6451.	1.21E+02	1.05E-04	5.07E-03	-8.01E-09	4.15E-04	0.
887.	396.	1.64E-08	8.12E-09	8.71	20.	2.50	0.	195.	73.	6425.	1.21E+02	1.04E-04	5.04E-03	-8.30E-09	4.12E-04	0.
900.	394.	1.64E-08	7.80E-09	8.93	20.	2.50	0.	200.	74.	6398.	1.21E+02	1.03E-04	5.00E-03	-8.58E-09	4.09E-04	0.
912.	392.	1.63E-08	7.51E-09	9.12	20.	2.50	0.	205.	75.	6372.	1.21E+02	1.03E-04	4.96E-03	-8.82E-09	4.07E-04	0.
925.	389.	1.63E-08	7.22E-09	9.30	20.	2.50	0.	210.	76.	6347.	1.21E+02	1.02E-04	4.93E-03	-9.06E-09	4.04E-04	0.
937.	387.	1.62E-08	6.95E-09	9.47	20.	2.50	0.	215.	76.	6322.	1.21E+02	1.01E-04	4.89E-03	-9.29E-09	4.01E-04	0.
950.	385.	1.62E-08	6.68E-09	9.63	19.	2.50	0.	220.	77.	6296.	1.21E+02	1.00E-04	4.86E-03	-9.51E-09	3.99E-04	0.
962.	382.	1.61E-08	6.42E-09	9.77	19.	2.50	0.	225.	78.	6270.	1.21E+02	9.95E-05	4.82E-03	-9.72E-09	3.96E-04	0.
975.	380.	1.61E-08	6.17E-09	9.90	19.	2.50	0.	230.	79.	6245.	1.21E+02	9.87E-05	4.79E-03	-9.92E-09	3.93E-04	0.
987.	377.	1.60E-08	5.93E-09	10.02	19.	2.50	0.	235.	80.	6219.	1.21E+02	9.79E-05	4.75E-03	-1.01E-08	3.91E-04	0.
1000.	375.	1.60E-08	5.70E-09	10.13	19.	2.50	0.	240.	81.	6194.	1.21E+02	9.72E-05	4.72E-03	-1.03E-08	3.88E-04	0.
1012.	373.	1.59E-08	5.46E-09	10.23	19.	2.50	0.	245.	82.	6167.	1.21E+02	9.64E-05	4.68E-03	-1.05E-08	3.85E-04	0.
1025.	370.	1.59E-08	5.23E-09	10.33	19.	2.50	0.	250.	83.	6140.	1.22E+02	9.56E-05	4.65E-03	-1.07E-08	3.83E-04	0.
1037.	368.	1.58E-08	5.01E-09	10.41	19.	2.50	0.	255.	84.	6113.	1.22E+02	9.48E-05	4.61E-03	-1.08E-08	3.80E-04	0.
1050.	365.	1.58E-08	4.79E-09	10.49	19.	2.50	0.	260.	85.	6086.	1.22E+02	9.40E-05	4.58E-03	-1.10E-08	3.77E-04	0.
1062.	363.	1.57E-08	4.59E-09	10.55	19.	2.50	0.	265.	86.	6059.	1.22E+02	9.32E-05	4.54E-03	-1.12E-08	3.74E-04	0.
1075.	360.	1.57E-08	4.39E-09	10.60	19.	2.50	0.	270.	87.	6032.	1.22E+02	9.24E-05	4.50E-03	-1.13E-08	3.72E-04	0.
1087.	357.	1.56E-08	4.19E-09	10.65	19.	2.50	0.	275.	88.	6005.	1.22E+02	9.17E-05	4.47E-03	-1.14E-08	3.69E-04	0.
1100.	355.	1.56E-08	4.01E-09	10.69	19.	2.50	0.	280.	89.	5978.	1.22E+02	9.09E-05	4.43E-03	-1.16E-08	3.66E-04	0.
1112.	353.	1.55E-08	3.84E-09	10.71	19.	2.50	0.	285.	90.	5952.	1.22E+02	9.01E-05	4.40E-03	-1.17E-08	3.63E-04	0.
1125.	350.	1.55E-08	3.68E-09	10.73	19.	2.50	0.	290.	91.	5926.	1.22E+02	8.94E-05	4.37E-03	-1.18E-08	3.61E-04	0.
1137.	348.	1.54E-08	3.52E-09	10.75	19.	2.50	0.	295.	92.	5900.	1.22E+02	8.87E-05	4.33E-03	-1.19E-08	3.58E-04	0.
1150.	346.	1.54E-08	3.37E-09	10.75	19.	2.50	0.	300.	94.	5874.	1.22E+02	8.80E-05	4.30E-03	-1.20E-08	3.56E-04	0.
1162.	343.	1.53E-08	3.22E-09	10.75	19.	2.50	0.	305.	95.	5848.	1.22E+02	8.72E-05	4.27E-03	-1.21E-08	3.53E-04	0.
1175.	341.	1.53E-08	3.08E-09	10.75	19.	2.50	0.	310.	96.	5823.	1.22E+02	8.65E-05	4.23E-03	-1.22E-08	3.51E-04	0.
1187.	338.	1.52E-08	2.94E-09	10.74	19.	2.50	0.	315.	97.	5797.	1.22E+02	8.58E-05	4.20E-03	-1.23E-08	3.48E-04	0.
1200.	336.	1.52E-08	2.81E-09	23.94	47.	1.60	0.	0.	98.	9017.	1.75E+02	8.51E-05	9.31E-03	-1.23E-08	4.94E-04	0.
1212.	336.	1.51E-08	2.80E-09	23.79	47.	1.60	0.	8.	98.	9012.	1.75E+02	8.50E-05	9.30E-03	-1.23E-08	4.93E-04	0.
1225.	335.	1.50E-08	2.78E-09	23.65	47.	1.60	0.	16.	99.	9008.	1.75E+02	8.49E-05	9.29E-03	-1.22E-08	4.93E-04	0.
1237.	335.	1.49E-08	2.77E-09	23.52	47.	1.60	0.	24.	99.	9004.	1.75E+02	8.49E-05	9.28E-03	-1.22E-08	4.93E-04	0.
1250.	335.	1.49E-08	2.76E-09	23.38	47.	1.60	0.	32.	99.	9000.	1.75E+02	8.48E-05	9.28E-03	-1.21E-08	4.92E-04	0.
1262.	335.	1.48E-08	2.74E-09	23.24	47.	1.60	0.	39.	99.	8995.	1.75E+02	8.47E-05	9.27E-03	-1.20E-08	4.92E-04	0.
1275.	335.	1.47E-08	2.73E-09	23.11	47.	1.60	0.	47.	99.	8991.	1.75E+02	8.46E-05	9.26E-03	-1.20E-08	4.91E-04	0.
1287.	334.	1.46E-08	2.72E-09	22.97	47.	1.60	0.	55.	99.	8987.	1.75E+02	8.46E-05	9.25E-03	-1.19E-08	4.91E-04	0.
1300.	334.	1.46E-08	2.70E-09	22.84	47.	1.60	0.	0.	99.	8983.	1.75E+02	8.45E-05	9.25E-03	-1.19E-08	4.91E-04	0.
1312.	334.	1.45E-08	2.70E-09	22.70	47.	1.60	0.	8.	99.	8980.	1.75E+02	8.44E-05	9.24E-03	-1.18E-08	4.90E-04	0.
1325.	334.	1.44E-08	2.69E-09	22.56	47.	1.60	0.	16.	99.	8978.	1.75E+02	8.44E-05	9.24E-03	-1.17E-08	4.90E-04	0.
1337.	334.	1.43E-08	2.68E-09	22.43	47.	1.60	0.	24.	100.	8976.	1.75E+02	8.44E-05	9.23E-03	-1.17E-08	4.90E-04	0.
1350.	334.	1.43E-08	2.68E-09	22.30	47.	1.60	0.	32.	100.	8974.	1.75E+02	8.43E-05	9.23E-03	-1.16E-08	4.90E-04	0.
1362.	333.	1.42E-08	2.67E-09	22.16	47.	1.60	0.	39.	100.	8972.	1.75E+02	8.43E-05	9.23E-03	-1.15E-08	4.90E-04	0.
1375.	333.	1.41E-08	2.67E-09	22.03	47.	1.60	0.	47.	100.	8970.	1.75E+02	8.43E-05	9.22E-03	-1.15E-08	4.90E-04	0.
1387.	333.	1.41E-08	2.66E-09	21.90	47.	1.60	0.	55.	100.	8968.	1.75E+02	8.42E-05	9.22E-03	-1.14E-08	4.89E-04	0.
1400.	333.	1.40E-08	2.65E-09	21.77	47.	1.60	0.	0.	100.	8965.	1.75E+02	8.42E-05	9.22E-03	-1.13E-08	4.89E-04	0.
1412.	333.	1.39E-08	2.65E-09	21.64	47.	1.60	0.	8.	100.	8963.	1.75E+02	8.41E-05	9.21E-03	-1.13E-08	4.89E-04	0.
1425.	333.	1.39E-08	2.64E-09	21.51	47.	1.60	0.	16.	100.	8961.	1.75E+02	8.41E-05	9.21E-03	-1.12E-08	4.89E-04	0.
1437.	333.	1.38E-08	2.63E-09	21.38	47.	1.60	0.	24.	100.	8959.	1.75E+02	8.41E-05	9.20E-03	-1.12E-08	4.89E-04	0.
1450.	332.	1.37E-08	2.63E-09	21.26	47.	1.60	0.	32.	100.	8957.	1.75E+02	8.40E-05	9.20E-03	-1.11E-08	4.88E-04	0.
1462.	332.	1.37E-08	2.62E-09	21.13	47.	1.60	0.	39.	100.	8955.	1.75E+02	8.40E-05	9.20E-03	-1.10E-08	4.88E-04	0.
1475.	332.	1.36E-08	2.61E-09	21.01	47.	1.60	0.	47.	100.	8953.	1.75E+02	8.40E-05	9.19E-03	-1.10E-08	4.88E-04	0.
1487.	332.	1.35E-08	2.61E-09	20.88	47.	1.60	0.	55.	100.	8951.	1.75E+02	8.39E-05	9.19E-03	-1.09E-08	4.88E-04	0.
1500.	332.	1.35E-08	2.60E-09	20.76	47.	1.60	0.	0.	100.	8948.	1.75E+02	8.39E-05	9.19E-03	-1.08E-08	4.88E-04	0.
1512.	332.	1.34E-08	2.59E-09	20.64	47.	1.60	0.	8.	101.	8944.	1.75E+02	8.38E-05	9.18E-03	-1.08E-08	4.87E-04	0.
1525.	332.	1.33E-08	2.58E-09	20.52	47.	1.60	0.	16.	101.	8940.	1.75E+02	8.37E-05	9.17E-03	-1.07E-08	4.87E-04	0.

1537.	331.	1.33E-08	2.56E-09	20.40	47.	1.60	0.	24.	101.	8936.	1.75E+02	8.37E-05	9.16E-03	-1.07E-08	4.86E-04	0.
1550.	331.	1.32E-08	2.55E-09	20.29	47.	1.60	0.	32.	101.	8931.	1.75E+02	8.36E-05	9.15E-03	-1.06E-08	4.86E-04	0.
1562.	331.	1.31E-08	2.54E-09	20.17	47.	1.60	0.	39.	101.	8927.	1.75E+02	8.35E-05	9.15E-03	-1.06E-08	4.86E-04	0.
1575.	331.	1.31E-08	2.53E-09	20.06	47.	1.60	0.	47.	101.	8923.	1.75E+02	8.34E-05	9.14E-03	-1.05E-08	4.85E-04	0.
1587.	330.	1.30E-08	2.51E-09	19.94	47.	1.60	0.	55.	101.	8918.	1.75E+02	8.34E-05	9.13E-03	-1.05E-08	4.85E-04	0.
1600.	330.	1.29E-08	2.50E-09	19.83	47.	1.60	0.	0.	101.	8914.	1.75E+02	8.33E-05	9.12E-03	-1.04E-08	4.85E-04	0.
1612.	330.	1.29E-08	2.50E-09	19.71	47.	1.60	0.	0.	102.	8912.	1.75E+02	8.33E-05	9.12E-03	-1.04E-08	4.84E-04	0.
1625.	330.	1.28E-08	2.49E-09	19.60	47.	1.60	0.	16.	102.	8910.	1.75E+02	8.32E-05	9.12E-03	-1.03E-08	4.84E-04	0.
1637.	330.	1.27E-08	2.48E-09	19.48	47.	1.60	0.	24.	102.	8908.	1.75E+02	8.32E-05	9.11E-03	-1.03E-08	4.84E-04	0.
1650.	329.	1.27E-08	2.48E-09	19.37	47.	1.60	0.	32.	102.	8906.	1.75E+02	8.31E-05	9.11E-03	-1.02E-08	4.84E-04	0.
1662.	329.	1.26E-08	2.47E-09	19.25	47.	1.60	0.	39.	102.	8904.	1.75E+02	8.31E-05	9.10E-03	-1.02E-08	4.84E-04	0.
1675.	329.	1.26E-08	2.46E-09	19.14	47.	1.60	0.	47.	102.	8901.	1.75E+02	8.31E-05	9.10E-03	-1.01E-08	4.83E-04	0.
1687.	329.	1.25E-08	2.46E-09	19.03	47.	1.60	0.	55.	102.	8899.	1.75E+02	8.30E-05	9.10E-03	-1.00E-08	4.83E-04	0.
1700.	329.	1.24E-08	2.45E-09	18.92	47.	1.60	0.	0.	102.	8897.	1.75E+02	8.30E-05	9.09E-03	-9.99E-09	4.83E-04	0.
1712.	329.	1.24E-08	2.45E-09	18.81	47.	1.60	0.	0.	102.	8895.	1.75E+02	8.30E-05	9.09E-03	-9.93E-09	4.83E-04	0.
1725.	329.	1.23E-08	2.44E-09	18.70	47.	1.60	0.	16.	102.	8893.	1.75E+02	8.29E-05	9.09E-03	-9.88E-09	4.83E-04	0.
1737.	329.	1.23E-08	2.43E-09	18.59	47.	1.60	0.	24.	102.	8891.	1.75E+02	8.29E-05	9.08E-03	-9.83E-09	4.82E-04	0.
1750.	329.	1.22E-08	2.43E-09	18.48	47.	1.60	0.	32.	102.	8889.	1.75E+02	8.28E-05	9.08E-03	-9.77E-09	4.82E-04	0.
1762.	328.	1.21E-08	2.42E-09	18.37	47.	1.60	0.	39.	102.	8886.	1.75E+02	8.28E-05	9.07E-03	-9.72E-09	4.82E-04	0.
1775.	328.	1.21E-09	2.42E-09	18.27	47.	1.60	0.	47.	102.	8884.	1.75E+02	8.28E-05	9.07E-03	-9.67E-09	4.82E-04	0.
1787.	328.	1.20E-08	2.41E-09	18.16	47.	1.60	0.	55.	102.	8882.	1.75E+02	8.27E-05	9.07E-03	-9.62E-09	4.82E-04	0.
1800.	328.	1.20E-08	2.40E-09	18.06	47.	1.60	0.	0.	103.	8880.	1.75E+02	8.27E-05	9.06E-03	-9.56E-09	4.82E-04	0.
1812.	328.	1.19E-08	2.40E-09	17.95	47.	1.60	0.	0.	103.	8878.	1.75E+02	8.27E-05	9.06E-03	-9.51E-09	4.81E-04	0.
1825.	328.	1.19E-08	2.39E-09	17.85	47.	1.60	0.	16.	103.	8876.	1.75E+02	8.26E-05	9.06E-03	-9.46E-09	4.81E-04	0.
1837.	328.	1.18E-08	2.39E-09	17.74	47.	1.60	0.	24.	103.	8874.	1.75E+02	8.26E-05	9.05E-03	-9.41E-09	4.81E-04	0.
1850.	328.	1.17E-08	2.38E-09	17.64	47.	1.60	0.	32.	103.	8871.	1.75E+02	8.25E-05	9.05E-03	-9.36E-09	4.81E-04	0.
1862.	327.	1.17E-08	2.38E-09	17.54	47.	1.60	0.	39.	103.	8869.	1.75E+02	8.25E-05	9.04E-03	-9.31E-09	4.81E-04	0.
1875.	327.	1.16E-08	2.37E-09	17.44	47.	1.60	0.	47.	103.	8867.	1.75E+02	8.25E-05	9.04E-03	-9.26E-09	4.80E-04	0.
1887.	327.	1.16E-08	2.36E-09	17.34	47.	1.60	0.	55.	103.	8865.	1.75E+02	8.24E-05	9.04E-03	-9.21E-09	4.80E-04	0.
1900.	327.	1.15E-08	2.36E-09	14.70	28.	3.25	2.50	1.	103.	2466.	7.01E+01	8.24E-05	7.70E-03	-9.16E-09	1.47E-03	0.
1912.	329.	1.14E-08	2.48E-09	12.00	28.	3.25	2.50	17.	102.	2478.	5.84E+01	8.31E-05	6.40E-03	-8.89E-09	1.24E-03	0.
1925.	332.	1.12E-08	2.60E-09	11.39	28.	3.25	2.50	34.	100.	2490.	5.66E+01	8.39E-05	6.33E-03	-8.63E-09	1.21E-03	0.
1937.	335.	1.11E-08	2.73E-09	10.98	28.	3.25	2.50	51.	99.	2502.	5.58E+01	8.46E-05	6.29E-03	-8.38E-09	1.20E-03	0.
1950.	337.	1.10E-08	2.87E-09	10.65	28.	3.25	2.50	67.	98.	2514.	5.53E+01	8.54E-05	6.30E-03	-8.12E-09	1.20E-03	0.
1962.	340.	1.09E-08	3.01E-09	10.36	28.	3.25	2.50	84.	97.	2526.	5.51E+01	8.61E-05	6.33E-03	-7.86E-09	1.21E-03	0.
1975.	342.	1.07E-08	3.15E-09	10.00	28.	3.25	2.50	101.	95.	2537.	5.50E+01	8.69E-05	6.37E-03	-7.60E-09	1.21E-03	0.
1987.	345.	1.06E-08	3.30E-09	9.81	28.	3.25	2.50	117.	94.	2549.	5.50E+01	8.77E-05	6.43E-03	-7.33E-09	1.22E-03	0.
2000.	347.	1.05E-08	3.46E-09	9.55	28.	3.25	2.50	133.	93.	2561.	5.50E+01	8.84E-05	6.49E-03	-7.06E-09	1.23E-03	0.
2012.	349.	1.04E-08	3.62E-09	9.28	28.	3.25	2.50	150.	92.	2572.	5.51E+01	8.91E-05	6.55E-03	-6.80E-09	1.25E-03	0.
2025.	352.	1.03E-08	3.78E-09	9.00	28.	3.25	2.50	167.	91.	2584.	5.52E+01	8.99E-05	6.62E-03	-6.53E-09	1.26E-03	0.
2037.	354.	1.02E-08	3.95E-09	8.72	28.	3.25	2.50	183.	90.	2595.	5.53E+01	9.06E-05	6.68E-03	-6.26E-09	1.27E-03	0.
2050.	357.	1.01E-08	4.12E-09	8.43	28.	3.25	2.50	200.	89.	2606.	5.55E+01	9.13E-05	6.75E-03	-5.99E-09	1.28E-03	0.
2062.	359.	1.00E-08	4.30E-09	8.13	28.	3.25	2.50	217.	87.	2617.	5.56E+01	9.21E-05	6.83E-03	-5.72E-09	1.30E-03	0.
2075.	361.	9.93E-09	4.49E-09	7.82	28.	3.25	2.50	233.	86.	2628.	5.57E+01	9.28E-05	6.90E-03	-5.44E-09	1.31E-03	0.
2087.	364.	9.84E-09	4.68E-09	7.50	28.	3.25	2.50	250.	85.	2640.	5.59E+01	9.36E-05	6.97E-03	-5.16E-09	1.32E-03	0.
2100.	366.	9.76E-09	4.88E-09	7.17	28.	3.25	2.50	267.	84.	2651.	5.60E+01	9.43E-05	7.05E-03	-4.88E-09	1.34E-03	0.
2112.	368.	9.68E-09	5.09E-09	6.81	28.	3.25	2.50	283.	83.	2662.	5.62E+01	9.51E-05	7.13E-03	-4.58E-09	1.35E-03	0.
2125.	371.	9.60E-09	5.32E-09	6.43	28.	3.25	2.50	300.	82.	2674.	5.64E+01	9.59E-05	7.21E-03	-4.28E-09	1.36E-03	0.
2137.	374.	9.53E-09	5.55E-09	6.04	28.	3.25	2.50	317.	81.	2686.	5.65E+01	9.67E-05	7.29E-03	-3.98E-09	1.38E-03	0.
2150.	376.	9.47E-09	5.79E-09	5.64	28.	3.25	2.50	333.	80.	2698.	5.67E+01	9.75E-05	7.37E-03	-3.67E-09	1.39E-03	0.
2162.	379.	9.40E-09	6.04E-09	5.22	28.	3.25	2.50	350.	79.	2709.	5.69E+01	9.83E-05	7.45E-03	-3.36E-09	1.41E-03	0.
2175.	381.	9.35E-09	6.30E-09	4.78	28.	3.25	2.50	367.	79.	2721.	5.70E+01	9.91E-05	7.53E-03	-3.04E-09	1.42E-03	0.
2187.	384.	9.30E-09	6.57E-09	4.32	28.	3.25	2.50	383.	78.	2733.	5.72E+01	9.99E-05	7.61E-03	-2.72E-09	1.44E-03	0.
2200.	386.	9.25E-09	6.85E-09	3.85	28.	3.25	2.50	400.	77.	2744.	5.73E+01	1.01E-04	7.69E-03	-2.40E-09	1.45E-03	0.
2212.	388.	9.21E-09	7.12E-09	3.38	28.	3.25	2.50	417.	76.	2755.	5.74E+01	1.01E-04	7.77E-03	-2.09E-09	1.47E-03	0.
2225.	391.	9.17E-09	7.40E-09	2.90	28.	3.25	2.50	433.	75.	2767.	5.76E+01	1.02E-04	7.85E-03	-1.77E-09	1.48E-03	0.
2237.	393.	9.14E-09	7.69E-09	2.40	28.	3.25	2.50	450.	74.	2778.	5.77E+01	1.03E-04	7.92E-03	-1.45E-09	1.49E-03	0.
2250.	396.	9.12E-09	7.99E-09	1.88	28.	3.25	2.50	467.	73.	2789.	5.78E+01	1.04E-04	8.00E-03	-1.13E-09	1.51E-03	0.
2262.	398.	9.10E-09	8.30E-09	1.35	28.	3.25	2.50	483.	73.	2800.	5.79E+01	1.05E-04	8.08E-03	-8.03E-10	1.52E-03	0.
2275.	400.	9.09E-09	8.61E-09	0.80	28.	3.25	2.50	500.	72.	2811.	5.80E+01	1.05E-04	8.15E-03	-4.74E-10	1.53E-03	0.

2287.	403.	9.00E-09	8.94E-09	0.24	28.	3.25	2.50	517.	71.	2822.	5.81E+01	1.06E-04	8.23E-03	-1.40E-10	1.55E-03	0.
2300.	405.	9.06E-09	9.28E-09	2.91	28.	3.25	2.50	533.	70.	2833.	5.82E+01	1.07E-04	8.30E-03	-1.60E-09	1.56E-03	0.
2312.	407.	9.03E-09	9.65E-09	2.30	28.	3.25	2.50	550.	69.	2844.	5.83E+01	1.08E-04	8.38E-03	-1.36E-09	1.58E-03	0.
2325.	410.	9.01E-09	1.00E-08	1.83	28.	3.25	2.50	567.	69.	2856.	5.84E+01	1.09E-04	8.46E-03	-1.04E-09	1.59E-03	0.
2337.	412.	8.99E-09	1.04E-08	1.26	28.	3.25	2.50	583.	68.	2868.	5.85E+01	1.09E-04	8.54E-03	-7.09E-10	1.60E-03	0.
2350.	415.	8.98E-09	1.08E-08	0.68	28.	3.25	2.50	600.	67.	2879.	5.86E+01	1.10E-04	8.62E-03	-3.78E-10	1.62E-03	0.
2362.	418.	8.98E-09	1.12E-08	0.08	28.	3.25	2.50	617.	66.	2891.	5.87E+01	1.11E-04	8.70E-03	-4.41E-11	1.63E-03	0.
2375.	420.	8.98E-09	1.17E-08	-0.54	28.	3.25	2.50	633.	66.	2902.	5.88E+01	1.12E-04	8.78E-03	2.93E-10	1.65E-03	0.
2387.	422.	8.99E-09	1.21E-08	-1.17	28.	3.25	2.50	650.	65.	2914.	5.89E+01	1.13E-04	8.86E-03	6.34E-10	1.66E-03	0.
2400.	425.	9.01E-09	1.26E-08	-1.82	28.	3.25	2.50	667.	64.	2925.	5.89E+01	1.14E-04	8.94E-03	9.78E-10	1.67E-03	0.
2412.	427.	9.03E-09	1.30E-08	-2.45	29.	3.25	2.50	683.	64.	2936.	5.90E+01	1.15E-04	9.01E-03	1.31E-09	1.69E-03	0.
2425.	430.	9.06E-09	1.35E-08	-3.10	29.	3.25	2.50	700.	63.	2947.	5.91E+01	1.15E-04	9.08E-03	1.64E-09	1.70E-03	0.
2437.	432.	9.10E-09	1.39E-08	-3.76	29.	3.25	2.50	717.	62.	2958.	5.91E+01	1.16E-04	9.16E-03	1.97E-09	1.71E-03	0.
2450.	434.	9.15E-09	1.44E-08	-4.44	29.	3.25	2.50	733.	62.	2969.	5.92E+01	1.17E-04	9.23E-03	2.31E-09	1.72E-03	0.
2462.	437.	9.20E-09	1.49E-08	-5.14	29.	3.25	2.50	750.	61.	2980.	5.92E+01	1.18E-04	9.31E-03	2.65E-09	1.74E-03	0.
2475.	439.	9.26E-09	1.54E-08	-5.85	29.	3.25	2.50	767.	60.	2991.	5.93E+01	1.19E-04	9.38E-03	2.99E-09	1.75E-03	0.
2487.	442.	9.33E-09	1.59E-08	-6.57	29.	3.25	2.50	783.	60.	3002.	5.93E+01	1.19E-04	9.45E-03	3.34E-09	1.76E-03	0.
2500.	444.	9.41E-09	1.65E-08	-7.32	29.	3.25	2.50	800.	59.	3013.	5.94E+01	1.20E-04	9.53E-03	3.69E-09	1.78E-03	0.
2512.	446.	9.50E-09	1.70E-08	-8.13	29.	3.25	2.50	817.	59.	3024.	5.94E+01	1.21E-04	9.60E-03	4.06E-09	1.79E-03	0.
2525.	449.	9.59E-09	1.76E-08	-8.96	29.	3.25	2.50	833.	58.	3035.	5.95E+01	1.22E-04	9.68E-03	4.44E-09	1.80E-03	0.
2537.	452.	9.70E-09	1.83E-08	-9.80	29.	3.25	2.50	850.	57.	3047.	5.95E+01	1.23E-04	9.76E-03	4.82E-09	1.82E-03	0.
2550.	454.	9.81E-09	1.89E-08	-10.67	29.	3.25	2.50	867.	57.	3058.	5.96E+01	1.24E-04	9.83E-03	5.21E-09	1.83E-03	0.
2562.	456.	9.93E-09	1.95E-08	-11.56	29.	3.25	2.50	883.	56.	3070.	5.96E+01	1.25E-04	9.91E-03	5.60E-09	1.84E-03	0.
2575.	459.	1.01E-08	2.02E-08	-12.47	29.	3.25	2.50	900.	56.	3081.	5.96E+01	1.26E-04	9.99E-03	6.00E-09	1.86E-03	0.
2587.	462.	1.02E-08	2.09E-08	-13.40	29.	3.25	2.50	917.	55.	3092.	5.97E+01	1.26E-04	1.01E-02	6.39E-09	1.87E-03	0.
2600.	464.	1.04E-08	2.16E-08	-14.36	29.	3.25	2.50	933.	54.	3104.	5.97E+01	1.27E-04	1.01E-02	6.80E-09	1.88E-03	0.
2612.	466.	1.05E-08	2.22E-08	-15.06	29.	3.25	2.50	950.	54.	3113.	5.97E+01	1.28E-04	1.02E-02	7.09E-09	1.89E-03	0.
2625.	468.	1.07E-08	2.27E-08	-15.78	29.	3.25	2.50	967.	54.	3122.	5.97E+01	1.29E-04	1.03E-02	7.38E-09	1.90E-03	0.
2637.	470.	1.09E-08	2.33E-08	-16.51	29.	3.25	2.50	983.	53.	3131.	5.98E+01	1.30E-04	1.03E-02	7.68E-09	1.91E-03	0.
2650.	472.	1.11E-08	2.39E-08	-17.25	29.	3.25	2.50	1000.	53.	3140.	5.98E+01	1.30E-04	1.04E-02	7.98E-09	1.92E-03	0.
2662.	474.	1.13E-08	2.46E-08	-18.00	29.	3.25	2.50	1017.	52.	3149.	5.98E+01	1.31E-04	1.04E-02	8.28E-09	1.94E-03	0.
2675.	476.	1.15E-08	2.52E-08	-18.77	29.	3.25	2.50	1033.	52.	3158.	5.98E+01	1.32E-04	1.05E-02	8.58E-09	1.95E-03	0.
2687.	478.	1.17E-08	2.59E-08	-19.54	29.	3.25	2.50	1050.	51.	3167.	5.98E+01	1.32E-04	1.06E-02	8.88E-09	1.96E-03	0.
2700.	480.	1.19E-08	2.65E-08	-27.07	49.	1.60	0.	0.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	9.19E-09	7.29E-04	0.
2712.	480.	1.20E-08	2.65E-08	-26.84	49.	1.60	0.	8.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	9.11E-09	7.29E-04	0.
2725.	480.	1.21E-08	2.65E-08	-26.59	49.	1.60	0.	16.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	9.02E-09	7.29E-04	0.
2737.	480.	1.21E-08	2.65E-08	-26.35	49.	1.60	0.	24.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.94E-09	7.29E-04	0.
2750.	480.	1.22E-08	2.65E-08	-26.11	49.	1.60	0.	32.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.86E-09	7.29E-04	0.
2762.	480.	1.23E-08	2.65E-08	-25.88	49.	1.60	0.	39.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.78E-09	7.29E-04	0.
2775.	480.	1.24E-08	2.65E-08	-25.64	49.	1.60	0.	47.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.70E-09	7.29E-04	0.
2787.	480.	1.25E-08	2.65E-08	-25.41	49.	1.60	0.	55.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.62E-09	7.29E-04	0.
2800.	480.	1.25E-08	2.65E-08	-25.18	49.	1.60	0.	0.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.54E-09	7.29E-04	0.
2812.	480.	1.26E-08	2.65E-08	-24.95	49.	1.60	0.	8.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.47E-09	7.29E-04	0.
2825.	480.	1.27E-08	2.65E-08	-24.72	49.	1.60	0.	16.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.39E-09	7.29E-04	0.
2837.	480.	1.28E-08	2.65E-08	-24.50	49.	1.60	0.	24.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.31E-09	7.29E-04	0.
2850.	480.	1.29E-08	2.65E-08	-24.28	49.	1.60	0.	32.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.24E-09	7.29E-04	0.
2862.	480.	1.29E-08	2.65E-08	-24.06	49.	1.60	0.	39.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.16E-09	7.29E-04	0.
2875.	480.	1.30E-08	2.65E-08	-23.84	49.	1.60	0.	47.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.09E-09	7.29E-04	0.
2887.	480.	1.31E-08	2.65E-08	-23.62	49.	1.60	0.	55.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	8.02E-09	7.29E-04	0.
2900.	480.	1.31E-08	2.65E-08	-23.41	49.	1.60	0.	0.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	7.94E-09	7.29E-04	0.
2912.	480.	1.32E-08	2.65E-08	-23.20	49.	1.60	0.	8.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	7.87E-09	7.29E-04	0.
2925.	480.	1.33E-08	2.65E-08	-22.99	49.	1.60	0.	16.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	7.80E-09	7.29E-04	0.
2937.	480.	1.34E-08	2.65E-08	-22.78	49.	1.60	0.	24.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	7.73E-09	7.29E-04	0.
2950.	480.	1.34E-08	2.65E-08	-22.57	49.	1.60	0.	32.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	7.66E-09	7.29E-04	0.
2957.	480.	1.35E-08	2.65E-08	-22.46	49.	1.60	0.	36.	51.	11415.	1.70E+02	1.33E-04	1.41E-02	7.62E-09	7.29E-04	0.

FOLLOWING TABLE SHOWS AXIAL DISTANCE X (CM),
TEMP T (C), CONCENTRATION AND SOLUBILITY C AND S (GMOL/CM3),
WALL FLUX N (NEG IS LOSS MG/CM2/MONTH), VEL V (CM/S).
DIAM D (CM), ANNULUS I.D. OR PLATE WIDTH W (CM), L/D,
SCHMIDT,REYNOLDS,NUSSELT NUMBERS, DIFFUSIVITY,MTC CGS,DELTA C, 4K/DV

X	TEMP	CONCENTN	SOLUBILTY	FLUX	VEL	DIAM	W	L/D	SCHM	REYNLD	NUSSELT	DFFUSVTY	MTC(CGS)	DELTA C	4K/DV	
12.	432.	7.77E-09	1.39E-08	-1.49	3.	6.00	0.	2.	62.	2835.	5.99E+01	1.16E-04	1.16E-03	6.17E-09	2.26E-04	0.
25.	434.	7.79E-09	1.42E-08	-1.54	3.	6.00	0.	4.	62.	2841.	5.94E+01	1.17E-04	1.16E-03	6.41E-09	2.25E-04	0.
37.	435.	7.81E-09	1.45E-08	-1.60	3.	6.00	0.	6.	62.	2846.	5.91E+01	1.17E-04	1.15E-03	6.64E-09	2.25E-04	0.
50.	436.	7.83E-09	1.47E-08	-1.66	3.	6.00	0.	8.	61.	2852.	5.89E+01	1.17E-04	1.15E-03	6.88E-09	2.25E-04	0.
62.	437.	7.85E-09	1.50E-08	-1.72	3.	6.00	0.	10.	61.	2857.	5.88E+01	1.18E-04	1.16E-03	7.13E-09	2.25E-04	0.
75.	438.	7.87E-09	1.52E-08	-1.78	3.	6.00	0.	13.	61.	2863.	5.87E+01	1.18E-04	1.16E-03	7.37E-09	2.25E-04	0.
87.	440.	7.89E-09	1.55E-08	-1.84	3.	6.00	0.	15.	60.	2868.	5.86E+01	1.19E-04	1.16E-03	7.62E-09	2.26E-04	0.
100.	441.	7.91E-09	1.58E-08	-1.91	3.	6.00	0.	17.	60.	2874.	5.85E+01	1.19E-04	1.16E-03	7.88E-09	2.26E-04	0.
113.	442.	7.94E-09	1.60E-08	-1.97	3.	6.00	0.	19.	60.	2879.	5.84E+01	1.20E-04	1.16E-03	8.10E-09	2.27E-04	0.
125.	443.	7.96E-09	1.63E-08	-2.03	3.	6.00	0.	21.	59.	2884.	5.84E+01	1.20E-04	1.17E-03	8.33E-09	2.27E-04	0.
138.	444.	7.98E-09	1.66E-08	-2.09	3.	6.00	0.	23.	59.	2889.	5.83E+01	1.20E-04	1.17E-03	8.57E-09	2.28E-04	0.
150.	446.	8.01E-09	1.68E-08	-2.15	3.	6.00	0.	25.	59.	2894.	5.83E+01	1.21E-04	1.17E-03	8.80E-09	2.28E-04	0.
163.	447.	8.03E-09	1.71E-08	-2.22	3.	6.00	0.	27.	59.	2899.	5.82E+01	1.21E-04	1.18E-03	9.04E-09	2.29E-04	0.
175.	448.	8.06E-09	1.73E-08	-2.28	3.	6.00	0.	29.	58.	2903.	5.82E+01	1.22E-04	1.18E-03	9.28E-09	2.29E-04	0.
188.	449.	8.09E-09	1.76E-08	-2.35	3.	6.00	0.	31.	58.	2908.	5.82E+01	1.22E-04	1.18E-03	9.52E-09	2.30E-04	0.
200.	450.	8.11E-09	1.79E-08	-22.60	68.	1.35	0.	0.	58.	12948.	1.96E+02	1.22E-04	1.78E-02	6.11E-09	7.76E-04	0.
212.	449.	8.18E-09	1.76E-08	-10.27	27.	1.35	0.	10.	58.	5145.	9.37E+01	1.22E-04	8.47E-03	5.82E-09	9.31E-04	0.
225.	448.	8.25E-09	1.73E-08	-9.75	27.	1.35	0.	19.	58.	5136.	9.37E+01	1.22E-04	8.44E-03	5.54E-09	9.28E-04	0.
237.	447.	8.31E-09	1.71E-08	-9.24	27.	1.35	0.	28.	59.	5127.	9.37E+01	1.21E-04	8.42E-03	5.27E-09	9.25E-04	0.
250.	446.	8.37E-09	1.68E-08	-8.74	27.	1.35	0.	37.	59.	5118.	9.38E+01	1.21E-04	8.39E-03	5.00E-09	9.23E-04	0.
262.	444.	8.43E-09	1.66E-08	-8.25	27.	1.35	0.	47.	59.	5110.	9.38E+01	1.20E-04	8.37E-03	4.74E-09	9.20E-04	0.
275.	443.	8.48E-09	1.63E-08	-7.78	27.	1.35	0.	56.	59.	5101.	9.38E+01	1.20E-04	8.34E-03	4.48E-09	9.18E-04	0.
288.	442.	8.53E-09	1.60E-08	-7.32	27.	1.35	0.	65.	60.	5092.	9.38E+01	1.20E-04	8.31E-03	4.23E-09	9.15E-04	0.
300.	441.	8.58E-09	1.58E-08	-28.22	129.	0.62	0.	1.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	3.98E-09	1.71E-03	0.
305.	441.	8.59E-09	1.58E-08	-11.33	129.	0.62	0.	1.	60.	11141.						
310.	441.	8.60E-09	1.58E-08	-8.00	129.	0.62	0.	1.	60.	11141.						
315.	441.	8.61E-09	1.58E-08	-6.52	129.	0.62	0.	1.	60.	11141.						
320.	441.	8.62E-09	1.58E-08	-5.64	129.	0.62	0.	1.	60.	11141.						
LENGTH REYNOLDS NUMBER=450000. AT 20.CM(32.DIAMS) INTO STRINGER #1																
332.	441.	8.70E-09	1.58E-08	-27.36	129.	0.62	0.	54.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	3.86E-09	1.71E-03	0.
345.	441.	8.78E-09	1.58E-08	-26.78	129.	0.62	0.	74.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	3.78E-09	1.71E-03	0.
357.	441.	8.86E-09	1.58E-08	-26.21	129.	0.62	0.	94.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	3.70E-09	1.71E-03	0.
370.	441.	8.94E-09	1.58E-08	-25.66	129.	0.62	0.	114.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	3.62E-09	1.71E-03	0.
382.	441.	9.02E-09	1.58E-08	-25.12	129.	0.62	0.	135.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	3.54E-09	1.71E-03	0.
395.	441.	9.09E-09	1.58E-08	-24.59	129.	0.62	0.	155.	60.	11141.	1.76E+02	1.19E-04	3.40E-02	3.47E-09	1.71E-03	0.
400.	441.	9.12E-09	1.58E-08	-2.06	8.	2.50	0.	0.	60.	2745.	6.03E+01	1.19E-04	2.88E-03	3.44E-09	5.87E-04	0.
212.	449.	8.20E-09	1.76E-08	-5.41	13.	1.35	0.	10.	58.	2456.	4.95E+01	1.22E-04	4.47E-03	5.81E-09	1.03E-03	0.
225.	448.	8.27E-09	1.73E-08	-4.92	13.	1.35	0.	19.	58.	2452.	4.75E+01	1.22E-04	4.27E-03	5.53E-09	9.84E-04	0.
237.	447.	8.33E-09	1.71E-08	-4.54	13.	1.35	0.	28.	59.	2448.	4.62E+01	1.21E-04	4.15E-03	5.25E-09	9.56E-04	0.
250.	446.	8.39E-09	1.68E-08	-4.21	13.	1.35	0.	37.	59.	2443.	4.53E+01	1.21E-04	4.06E-03	4.98E-09	9.35E-04	0.
262.	444.	8.45E-09	1.66E-08	-3.91	13.	1.35	0.	47.	59.	2439.	4.46E+01	1.20E-04	3.98E-03	4.72E-09	9.17E-04	0.
275.	443.	8.50E-09	1.63E-08	-3.63	13.	1.35	0.	56.	59.	2435.	4.40E+01	1.20E-04	3.91E-03	4.46E-09	9.01E-04	0.
288.	442.	8.55E-09	1.60E-08	-3.37	13.	1.35	0.	65.	60.	2431.	4.34E+01	1.20E-04	3.85E-03	4.21E-09	8.86E-04	0.
300.	441.	8.60E-09	1.58E-08	-15.56	62.	0.62	0.	1.	60.	5319.	9.73E+01	1.19E-04	1.88E-02	3.97E-09	1.98E-03	0.
305.	441.	8.62E-09	1.58E-08	-7.81	62.	0.62	0.	1.	60.	5319.						
310.	441.	8.63E-09	1.58E-08	-5.51	62.	0.62	0.	1.	60.	5319.						
315.	441.	8.64E-09	1.58E-08	-4.49	62.	0.62	0.	1.	60.	5319.						
320.	441.	8.65E-09	1.58E-08	-3.88	62.	0.62	0.	1.	60.	5319.						
325.	441.	8.66E-09	1.58E-08	-3.47	62.	0.62	0.	1.	60.	5319.						
330.	441.	8.67E-09	1.58E-08	-3.16	62.	0.62	0.	1.	60.	5319.						
335.	441.	8.67E-09	1.58E-08	-2.92	62.	0.62	0.	1.	60.	5319.						
340.	441.	8.68E-09	1.58E-08	-2.73	62.	0.62	0.	1.	60.	5319.						
345.	441.	8.69E-09	1.58E-08	-2.57	62.	0.62	0.	1.	60.	5319.						
350.	441.	8.69E-09	1.58E-08	-2.44	62.	0.62	0.	1.	60.	5319.						
LI|IGTH REYNOLDS NUMBER=450000. AT 50.CM(81.DIAMS) INTO STRINGER #2																
363.	441.	8.79E-09	1.58E-08	-14.79	62.	0.62	0.	102.	60.	5319.	9.73E+01	1.19E-04	1.88E-02	3.77E-09	1.98E-03	0.
375.	441.	8.88E-09	1.58E-08	-14.43	62.	0.62	0.	123.	60.	5319.	9.73E+01	1.19E-04	1.88E-02	3.68E-09	1.98E-03	0.
388.	441.	8.97E-09	1.58E-08	-14.08	62.	0.62	0.	143.	60.	5319.	9.73E+01	1.19E-04	1.88E-02	3.59E-09	1.98E-03	0.

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400. 441. 9.06E-09 1.58E-08 -3.95   4. 2.50 0.     0.  60.  1310. 1.14E+02 1.19E-04 5.42E-03 3.50E-09 2.31E-03  0.
212. 449. 8.22E-09 1.76E-08 -3.71   9. 1.35 0.    10.  58.  1693. 3.41E+01 1.22E-04 3.00E-03 5.79E-09 1.03E-03  0.
225. 448. 8.20E-09 1.73E-08 -2.82   9. 1.35 0.    19.  58.  1690. 2.73E+01 1.22E-04 2.46E-03 5.51E-09 8.21E-04  0.
237. 447. 8.34E-09 1.71E-08 -2.35   9. 1.35 0.    28.  59.  1688. 2.40E+01 1.21E-04 2.15E-03 5.25E-09 7.19E-04  0.
250. 446. 8.38E-09 1.68E-08 -2.03   9. 1.35 0.    37.  59.  1685. 2.10E+01 1.21E-04 1.95E-03 4.99E-09 6.53E-04  0.
262. 444. 8.42E-09 1.66E-08 -1.79   9. 1.35 0.    47.  59.  1682. 2.03E+01 1.20E-04 1.81E-03 4.75E-09 6.06E-04  0.
275. 443. 8.45E-09 1.63E-08 -1.60   9. 1.35 0.    56.  59.  1679. 1.92E+01 1.20E-04 1.70E-03 4.51E-09 5.69E-04  0.
288. 442. 8.48E-09 1.60E-08 -1.44   9. 1.35 0.    65.  60.  1676. 1.82E+01 1.20E-04 1.62E-03 4.28E-09 5.40E-04  0.
300. 441. 8.51E-09 1.58E-08-11.81  43. 0.62 0.     1.  60.  3667. 7.23E+01 1.19E-04 1.40E-02 4.05E-09 2.14E-03  0.
305. 441. 8.54E-09 1.58E-08 -6.56  43. 0.62 0.     1.  60.  3667.
310. 441. 8.55E-09 1.58E-08 -4.62  43. 0.62 0.     1.  60.  3667.
315. 441. 8.57E-09 1.58E-08 -3.77  43. 0.62 0.     1.  60.  3667.
320. 441. 8.58E-09 1.58E-08 -3.26  43. 0.62 0.     1.  60.  3667.
325. 441. 8.59E-09 1.58E-08 -2.91  43. 0.62 0.     1.  60.  3667.
330. 441. 8.60E-09 1.58E-08 -2.65  43. 0.62 0.     1.  60.  3667.
335. 441. 8.61E-09 1.58E-08 -2.45  43. 0.62 0.     1.  60.  3667.
340. 441. 8.62E-09 1.58E-08 -2.29  43. 0.62 0.     1.  60.  3667.
345. 441. 8.62E-09 1.58E-08 -2.16  43. 0.62 0.     1.  60.  3667.
350. 441. 8.63E-09 1.58E-08 -2.04  43. 0.62 0.     1.  60.  3667.
355. 441. 8.64E-09 1.58E-08 -1.95  43. 0.62 0.     1.  60.  3667.
360. 441. 8.65E-09 1.58E-08 -1.86  43. 0.62 0.     1.  60.  3667.
365. 441. 8.65E-09 1.58E-08 -1.79  43. 0.62 0.     1.  60.  3667.
370. 441. 8.66E-09 1.58E-08 -1.72  43. 0.62 0.     1.  60.  3667.
375. 441. 8.66E-09 1.58E-08 -1.66  43. 0.62 0.     1.  60.  3667.
LENGTH REYNOLDS NUMBER=450000. AT 75.CM(122.DIAMS) INTO STRINGER #3
388. 441. 8.77E-09 1.58E-08-11.02  43. 0.62 0.   143.  60.  3667. 7.21E+01 1.19E-04 1.39E-02 3.79E-09 2.13E-03  0.
400. 441. 8.87E-09 1.58E-08 -3.69   3. 2.50 0.     0.  60.   904. 1.01E+02 1.19E-04 4.79E-03 3.69E-09 2.97E-03  0.
212. 449. 8.19E-09 1.76E-08 -7.76  19. 1.35 0.    10.  58.  3632. 7.09E+01 1.22E-04 6.40E-03 5.82E-09 9.97E-04  0.
225. 448. 8.26E-09 1.73E-08 -7.35  19. 1.35 0.    19.  58.  3626. 7.08E+01 1.22E-04 6.38E-03 5.53E-09 9.93E-04  0.
237. 447. 8.33E-09 1.71E-08 -6.96  19. 1.35 0.    28.  59.  3620. 7.08E+01 1.21E-04 6.36E-03 5.25E-09 9.90E-04  0.
250. 446. 8.39E-09 1.68E-08 -6.58  19. 1.35 0.    37.  59.  3614. 7.08E+01 1.21E-04 6.34E-03 4.98E-09 9.87E-04  0.
262. 444. 8.45E-09 1.66E-08 -6.20  19. 1.35 0.    47.  59.  3608. 7.08E+01 1.20E-04 6.32E-03 4.72E-09 9.84E-04  0.
275. 443. 8.51E-09 1.63E-08 -5.84  19. 1.35 0.    56.  59.  3601. 7.08E+01 1.20E-04 6.30E-03 4.45E-09 9.81E-04  0.
288. 442. 8.56E-09 1.60E-08 -5.49  19. 1.35 0.    65.  60.  3595. 7.08E+01 1.20E-04 6.28E-03 4.20E-09 9.78E-04  0.
300. 441. 8.61E-09 1.58E-08-21.20  91. 0.62 0.     1.  60.  7866. 1.33E+02 1.19E-04 2.58E-02 3.95E-09 1.83E-03  0.
305. 441. 8.63E-09 1.58E-08 -9.48  91. 0.62 0.     1.  60.  7866.
310. 441. 8.64E-09 1.58E-08 -6.69  91. 0.62 0.     1.  60.  7866.
315. 441. 8.65E-09 1.58E-08 -5.45  91. 0.62 0.     1.  60.  7866.
320. 441. 8.65E-09 1.58E-08 -4.72  91. 0.62 0.     1.  60.  7866.
325. 441. 8.66E-09 1.58E-08 -4.21  91. 0.62 0.     1.  60.  7866.
330. 441. 8.67E-09 1.58E-08 -3.84  91. 0.62 0.     1.  60.  7866.
335. 441. 8.67E-09 1.58E-08 -3.55  91. 0.62 0.     1.  60.  7866.
LENGTH REYNOLDS NUMBER=450000. AT 35.CM( 57.DIAMS) INTO STRINGER #4
348. 441. 8.76E-09 1.58E-08-20.37  91. 0.62 0.    78.  60.  7866. 1.33E+02 1.19E-04 2.58E-02 3.80E-09 1.83E-03  0.
360. 441. 8.85E-09 1.58E-08-19.91  91. 0.62 0.    98.  60.  7866. 1.33E+02 1.19E-04 2.58E-02 3.71E-09 1.83E-03  0.
373. 441. 8.93E-09 1.58E-08-19.46  91. 0.62 0.   119.  60.  7866. 1.33E+02 1.19E-04 2.58E-02 3.63E-09 1.83E-03  0.
385. 441. 9.01E-09 1.58E-08-19.02  91. 0.62 0.   139.  60.  7866. 1.33E+02 1.19E-04 2.58E-02 3.54E-09 1.83E-03  0.
398. 441. 9.09E-09 1.58E-08-18.59  91. 0.62 0.   159.  60.  7866. 1.33E+02 1.19E-04 2.58E-02 3.46E-09 1.83E-03  0.
400. 441. 9.11E-09 1.58E-08 -4.43   6. 2.50 0.     0.  60.  1938. 1.29E+02 1.19E-04 6.17E-03 3.45E-09 1.78E-03  0.
412. 440. 9.09E-09 1.55E-08 -3.83  20. 2.50 0.     5.  60.  6883. 1.20E+02 1.19E-04 5.69E-03 3.23E-09 4.62E-04  0.
425. 438. 9.11E-09 1.52E-08 -3.51  20. 2.50 0.    10.  61.  6868. 1.20E+02 1.18E-04 5.67E-03 2.97E-09 4.60E-04  0.
437. 437. 9.13E-09 1.49E-08 -3.21  20. 2.50 0.    15.  61.  6854. 1.20E+02 1.18E-04 5.65E-03 2.72E-09 4.59E-04  0.
450. 435. 9.14E-09 1.46E-08 -2.91  20. 2.50 0.    20.  61.  6839. 1.20E+02 1.17E-04 5.63E-03 2.48E-09 4.57E-04  0.
462. 434. 9.15E-09 1.43E-08 -2.62  20. 2.50 0.    25.  62.  6825. 1.20E+02 1.17E-04 5.61E-03 2.24E-09 4.55E-04  0.
475. 433. 9.17E-09 1.40E-08 -2.33  20. 2.50 0.    30.  62.  6810. 1.20E+02 1.16E-04 5.59E-03 2.01E-09 4.54E-04  0.
487. 431. 9.18E-09 1.38E-08 -2.06  20. 2.50 0.    35.  62.  6796. 1.20E+02 1.16E-04 5.56E-03 1.78E-09 4.52E-04  0.
500. 430. 9.19E-09 1.35E-08 -1.79  20. 2.50 0.    40.  63.  6781. 1.20E+02 1.15E-04 5.54E-03 1.55E-09 4.51E-04  0.
512. 429. 9.20E-09 1.32E-08 -1.53  20. 2.50 0.    45.  63.  6767. 1.20E+02 1.15E-04 5.52E-03 1.33E-09 4.49E-04  0.
525. 427. 9.20E-09 1.30E-08 -1.28  20. 2.50 0.    50.  64.  6752. 1.20E+02 1.14E-04 5.50E-03 1.12E-09 4.47E-04  0.
537. 426. 9.21E-09 1.27E-08 -1.03  20. 2.50 0.    55.  64.  6737. 1.20E+02 1.14E-04 5.48E-03 9.06E-10 4.46E-04  0.
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550.	[illegible]	[illegible]	[illegible]	[illegible]	20.	2.50	0.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
562.	423.	9.22E-09	1.22E-08	-0.56	20.	2.50	0.	65.	65.	6708.	1.20E+02	1.13E-04	5.44E-03 4.90E-10 4.43E-04 0.
575.	422.	9.22E-09	1.20E-08	-0.34	20.	2.50	0.	70.	65.	6694.	1.20E+02	1.13E-04	5.42E-03 3.00E-10 4.41E-04 0.
587.	420.	9.22E-09	1.17E-08	-0.12	20.	2.50	0.	75.	66.	6679.	1.20E+02	1.12E-04	5.39E-03 1.07E-10 4.40E-04 0.
600.	419.	9.22E-09	1.15E-08	0.09	20.	2.50	0.	80.	66.	6664.	1.20E+02	1.12E-04	5.37E-03-8.23E-11 4.38E-04 0.
612.	418.	9.22E-09	1.12E-08	0.32	20.	2.50	0.	85.	66.	6649.	1.20E+02	1.11E-04	5.35E-03-2.04E-10 4.36E-04 0.
625.	416.	9.22E-09	1.10E-08	0.53	20.	2.50	0.	90.	67.	6633.	1.20E+02	1.11E-04	5.33E-03-4.81E-10 4.34E-04 0.
637.	415.	9.21E-09	1.07E-08	0.74	20.	2.50	0.	95.	67.	6617.	1.20E+02	1.10E-04	5.31E-03-6.73E-10 4.33E-04 0.
650.	413.	9.21E-09	1.05E-08	0.95	20.	2.50	0.	100.	68.	6601.	1.20E+02	1.10E-04	5.28E-03-8.61E-10 4.31E-04 0.
662.	412.	9.20E-09	1.03E-08	1.14	20.	2.50	0.	105.	68.	6585.	1.21E+02	1.09E-04	5.26E-03-1.04E-09 4.29E-04 0.
675.	410.	9.20E-09	1.00E-08	1.33	20.	2.50	0.	110.	69.	6569.	1.21E+02	1.09E-04	5.24E-03-1.22E-09 4.28E-04 0.
687.	409.	9.19E-09	9.80E-09	1.52	20.	2.50	0.	115.	69.	6553.	1.21E+02	1.08E-04	5.21E-03-1.40E-09 4.26E-04 0.
700.	407.	9.18E-09	9.57E-09	1.70	20.	2.50	0.	120.	70.	6537.	1.21E+02	1.08E-04	5.19E-03-1.57E-09 4.24E-04 0.
712.	406.	9.17E-09	9.37E-09	1.85	20.	2.50	0.	125.	70.	6522.	1.21E+02	1.07E-04	5.17E-03-1.72E-09 4.23E-04 0.
725.	404.	9.16E-09	9.17E-09	2.00	20.	2.50	0.	130.	70.	6507.	1.21E+02	1.07E-04	5.15E-03-1.87E-09 4.21E-04 0.
737.	403.	9.16E-09	8.98E-09	0.20	20.	2.50	0.	135.	71.	6493.	1.21E+02	1.06E-04	5.13E-03-1.86E-10 4.19E-04 0.
750.	402.	9.16E-09	8.79E-09	0.40	20.	2.50	0.	140.	71.	6478.	1.21E+02	1.06E-04	5.11E-03-3.76E-10 4.18E-04 0.
762.	400.	9.16E-09	8.60E-09	0.60	20.	2.50	0.	145.	72.	6463.	1.21E+02	1.05E-04	5.09E-03-5.62E-10 4.16E-04 0.
775.	399.	9.16E-09	8.41E-09	0.78	20.	2.50	0.	150.	72.	6449.	1.21E+02	1.05E-04	5.07E-03-7.43E-10 4.15E-04 0.
787.	397.	9.15E-09	8.23E-09	0.97	20.	2.50	0.	155.	73.	6434.	1.21E+02	1.04E-04	5.05E-03-9.20E-10 4.13E-04 0.
800.	396.	9.15E-09	8.05E-09	1.15	20.	2.50	0.	160.	73.	6419.	1.21E+02	1.04E-04	5.03E-03-1.09E-09 4.12E-04 0.
812.	395.	9.14E-09	7.88E-09	1.32	20.	2.50	0.	165.	74.	6405.	1.21E+02	1.04E-04	5.01E-03-1.26E-09 4.10E-04 0.
825.	393.	9.13E-09	7.71E-09	1.48	20.	2.50	0.	170.	74.	6390.	1.21E+02	1.03E-04	4.99E-03-1.43E-09 4.09E-04 0.
837.	392.	9.13E-09	7.54E-09	1.64	20.	2.50	0.	175.	75.	6375.	1.21E+02	1.03E-04	4.97E-03-1.59E-09 4.07E-04 0.
850.	390.	9.12E-09	7.37E-09	1.80	20.	2.50	0.	180.	75.	6360.	1.21E+02	1.02E-04	4.95E-03-1.75E-09 4.05E-04 0.
862.	389.	9.11E-09	7.21E-09	1.95	20.	2.50	0.	185.	76.	6346.	1.21E+02	1.02E-04	4.93E-03-1.90E-09 4.04E-04 0.
875.	388.	9.10E-09	7.05E-09	2.10	20.	2.50	0.	190.	76.	6331.	1.21E+02	1.01E-04	4.91E-03-2.05E-09 4.02E-04 0.
887.	386.	9.09E-09	6.89E-09	2.24	20.	2.50	0.	195.	77.	6316.	1.21E+02	1.01E-04	4.89E-03-2.20E-09 4.01E-04 0.
900.	385.	9.08E-09	6.74E-09	2.37	19.	2.50	0.	200.	77.	6301.	1.21E+02	1.00E-04	4.87E-03-2.34E-09 3.99E-04 0.
912.	384.	9.06E-09	6.57E-09	2.52	19.	2.50	0.	205.	78.	6285.	1.21E+02	9.99E-05	4.84E-03-2.49E-09 3.98E-04 0.
925.	382.	9.05E-09	6.41E-09	2.65	19.	2.50	0.	210.	78.	6269.	1.21E+02	9.94E-05	4.82E-03-2.64E-09 3.96E-04 0.
937.	381.	9.04E-09	6.25E-09	2.79	19.	2.50	0.	215.	79.	6253.	1.21E+02	9.89E-05	4.80E-03-2.79E-09 3.94E-04 0.
950.	379.	9.02E-09	6.10E-09	2.92	19.	2.50	0.	220.	79.	6237.	1.21E+02	9.85E-05	4.78E-03-2.93E-09 3.93E-04 0.
962.	378.	9.01E-09	5.94E-09	3.04	19.	2.50	0.	225.	80.	6221.	1.21E+02	9.80E-05	4.76E-03-3.07E-09 3.91E-04 0.
975.	376.	8.99E-09	5.79E-09	3.16	19.	2.50	0.	230.	80.	6205.	1.21E+02	9.75E-05	4.73E-03-3.20E-09 3.89E-04 0.
987.	375.	8.98E-09	5.65E-09	3.27	19.	2.50	0.	235.	81.	6188.	1.21E+02	9.70E-05	4.71E-03-3.33E-09 3.88E-04 0.
1000.	373.	8.96E-09	5.51E-09	3.38	19.	2.50	0.	240.	82.	6172.	1.21E+02	9.65E-05	4.69E-03-3.46E-09 3.86E-04 0.
1012.	372.	8.94E-09	5.39E-09	3.46	19.	2.50	0.	245.	82.	6159.	1.22E+02	9.61E-05	4.67E-03-3.56E-09 3.84E-04 0.
1025.	371.	8.93E-09	5.27E-09	3.54	19.	2.50	0.	250.	83.	6145.	1.22E+02	9.57E-05	4.65E-03-3.65E-09 3.83E-04 0.
1037.	369.	8.91E-09	5.16E-09	3.62	19.	2.50	0.	255.	83.	6132.	1.22E+02	9.53E-05	4.64E-03-3.75E-09 3.82E-04 0.
1050.	368.	8.89E-09	5.05E-09	3.70	19.	2.50	0.	260.	84.	6118.	1.22E+02	9.49E-05	4.62E-03-3.84E-09 3.80E-04 0.
1062.	367.	8.87E-09	4.94E-09	3.77	19.	2.50	0.	265.	84.	6105.	1.22E+02	9.46E-05	4.60E-03-3.93E-09 3.79E-04 0.
1075.	365.	8.85E-09	4.83E-09	3.84	19.	2.50	0.	270.	85.	6091.	1.22E+02	9.42E-05	4.58E-03-4.02E-09 3.78E-04 0.
1087.	364.	8.84E-09	4.73E-09	3.90	19.	2.50	0.	275.	85.	6078.	1.22E+02	9.38E-05	4.56E-03-4.11E-09 3.76E-04 0.
1100.	363.	8.82E-09	4.63E-09	3.97	19.	2.50	0.	280.	86.	6064.	1.22E+02	9.34E-05	4.55E-03-4.19E-09 3.75E-04 0.
1112.	362.	8.80E-09	4.52E-09	4.04	19.	2.50	0.	285.	86.	6049.	1.22E+02	9.29E-05	4.53E-03-4.28E-09 3.73E-04 0.
1125.	360.	8.78E-09	4.41E-09	4.10	19.	2.50	0.	290.	87.	6034.	1.22E+02	9.25E-05	4.51E-03-4.37E-09 3.72E-04 0.
1137.	359.	8.76E-09	4.30E-09	4.17	19.	2.50	0.	295.	87.	6020.	1.22E+02	9.21E-05	4.49E-03-4.46E-09 3.70E-04 0.
1150.	357.	8.73E-09	4.19E-09	4.23	19.	2.50	0.	300.	88.	6005.	1.22E+02	9.17E-05	4.47E-03-4.54E-09 3.69E-04 0.
1162.	356.	8.71E-09	4.09E-09	4.28	19.	2.50	0.	305.	89.	5990.	1.22E+02	9.12E-05	4.45E-03-4.62E-09 3.67E-04 0.
1175.	355.	8.69E-09	3.99E-09	4.34	19.	2.50	0.	310.	89.	5975.	1.22E+02	9.08E-05	4.43E-03-4.70E-09 3.66E-04 0.
1187.	353.	8.67E-09	3.89E-09	4.39	19.	2.50	0.	315.	90.	5960.	1.22E+02	9.04E-05	4.41E-03-4.78E-09 3.64E-04 0.
1200.	352.	8.65E-09	3.80E-09	9.91	47.	1.60	0.	0.	91.	9209.	1.74E+02	9.00E-05	9.81E-03-4.85E-09 5.18E-04 0.
1212.	352.	8.62E-09	3.79E-09	9.86	47.	1.60	0.	8.	91.	9207.	1.74E+02	8.99E-05	9.80E-03-4.83E-09 5.18E-04 0.
1225.	352.	8.59E-09	3.78E-09	9.81	47.	1.60	0.	16.	91.	9205.	1.74E+02	8.99E-05	9.80E-03-4.81E-09 5.18E-04 0.
1237.	352.	8.56E-09	3.77E-09	9.76	47.	1.60	0.	24.	91.	9283.	1.74E+02	8.98E-05	9.79E-03-4.78E-09 5.18E-04 0.
1250.	352.	8.52E-09	3.76E-09	9.71	47.	1.60	0.	32.	91.	9281.	1.74E+02	8.98E-05	9.79E-03-4.76E-09 5.18E-04 0.
1262.	351.	8.49E-09	3.75E-09	9.66	47.	1.60	0.	39.	91.	9278.	1.74E+02	8.98E-05	9.79E-03-4.74E-09 5.17E-04 0.
1275.	351.	8.46E-09	3.74E-09	9.61	47.	1.60	0.	47.	91.	9276.	1.74E+02	8.97E-05	9.78E-03-4.72E-09 5.17E-04 0.
1287.	351.	8.43E-09	3.74E-09	9.57	47.	1.60	0.	55.	91.	9274.	1.74E+02	8.97E-05	9.78E-03-4.70E-09 5.17E-04 0.

1300.	351.	8.40E-09	3.73E-09	9.52	47.	1.60	0.	0.	91.	9272.	1.74E+02	8.96E-05	9.77E-03	-4.67E-09	5.17E-04	0.
1312.	351.	8.37E-09	3.71E-09	9.48	47.	1.60	0.	8.	91.	9268.	1.74E+02	8.96E-05	9.77E-03	-4.66E-09	5.17E-04	0.
1325.	351.	8.34E-09	3.69E-09	9.45	47.	1.60	0.	16.	91.	9264.	1.74E+02	8.95E-05	9.76E-03	-4.65E-09	5.16E-04	0.
1337.	350.	8.31E-09	3.68E-09	9.42	47.	1.60	0.	24.	91.	9259.	1.74E+02	8.94E-05	9.75E-03	-4.64E-09	5.16E-04	0.
1350.	350.	8.28E-09	3.66E-09	9.38	47.	1.60	0.	32.	91.	9255.	1.74E+02	8.93E-05	9.74E-03	-4.62E-09	5.15E-04	0.
1362.	350.	8.25E-09	3.64E-09	9.35	47.	1.60	0.	39.	92.	9251.	1.74E+02	8.93E-05	9.73E-03	-4.61E-09	5.15E-04	0.
1375.	350.	8.22E-09	3.63E-09	9.31	47.	1.60	0.	47.	92.	9247.	1.75E+02	8.92E-05	9.73E-03	-4.60E-09	5.15E-04	0.
1387.	349.	8.19E-09	3.61E-09	9.28	47.	1.60	0.	55.	92.	9242.	1.75E+02	8.91E-05	9.72E-03	-4.58E-09	5.14E-04	0.
1400.	349.	8.16E-09	3.59E-09	9.25	47.	1.60	0.	0.	92.	9238.	1.75E+02	8.90E-05	9.71E-03	-4.57E-09	5.14E-04	0.
1412.	349.	8.13E-09	3.58E-09	9.20	47.	1.60	0.	8.	92.	9236.	1.75E+02	8.90E-05	9.71E-03	-4.55E-09	5.14E-04	0.
1425.	349.	8.11E-09	3.58E-09	9.16	47.	1.60	0.	16.	92.	9234.	1.75E+02	8.90E-05	9.70E-03	-4.53E-09	5.13E-04	0.
1437.	349.	8.08E-09	3.57E-09	9.11	47.	1.60	0.	24.	92.	9232.	1.75E+02	8.89E-05	9.70E-03	-4.51E-09	5.13E-04	0.
1450.	349.	8.05E-09	3.56E-09	9.06	47.	1.60	0.	32.	92.	9230.	1.75E+02	8.89E-05	9.70E-03	-4.49E-09	5.13E-04	0.
1462.	348.	8.02E-09	3.55E-09	9.02	47.	1.60	0.	39.	92.	9227.	1.75E+02	8.88E-05	9.69E-03	-4.47E-09	5.13E-04	0.
1475.	348.	7.99E-09	3.54E-09	8.97	47.	1.60	0.	47.	92.	9225.	1.75E+02	8.88E-05	9.69E-03	-4.45E-09	5.13E-04	0.
1487.	348.	7.96E-09	3.53E-09	8.93	47.	1.60	0.	55.	92.	9223.	1.75E+02	8.88E-05	9.68E-03	-4.43E-09	5.12E-04	0.
1500.	348.	7.93E-09	3.53E-09	8.89	47.	1.60	0.	0.	92.	9221.	1.75E+02	8.87E-05	9.68E-03	-4.41E-09	5.12E-04	0.
1512.	348.	7.91E-09	3.51E-09	8.86	47.	1.60	0.	8.	93.	9217.	1.75E+02	8.87E-05	9.67E-03	-4.40E-09	5.12E-04	0.
1525.	348.	7.88E-09	3.49E-09	8.82	47.	1.60	0.	16.	93.	9213.	1.75E+02	8.86E-05	9.66E-03	-4.38E-09	5.11E-04	0.
1537.	347.	7.85E-09	3.48E-09	8.79	47.	1.60	0.	24.	93.	9208.	1.75E+02	8.85E-05	9.66E-03	-4.37E-09	5.11E-04	0.
1550.	347.	7.82E-09	3.46E-09	8.76	47.	1.60	0.	32.	93.	9204.	1.75E+02	8.84E-05	9.65E-03	-4.36E-09	5.11E-04	0.
1562.	347.	7.79E-09	3.45E-09	8.73	47.	1.60	0.	39.	93.	9200.	1.75E+02	8.83E-05	9.64E-03	-4.35E-09	5.10E-04	0.
1575.	346.	7.77E-09	3.43E-09	8.70	47.	1.60	0.	47.	93.	9196.	1.75E+02	8.83E-05	9.63E-03	-4.34E-09	5.10E-04	0.
1587.	346.	7.74E-09	3.41E-09	8.67	47.	1.60	0.	55.	93.	9191.	1.75E+02	8.82E-05	9.63E-03	-4.32E-09	5.10E-04	0.
1600.	346.	7.71E-09	3.40E-09	8.64	47.	1.60	0.	0.	93.	9187.	1.75E+02	8.81E-05	9.62E-03	-4.31E-09	5.09E-04	0.
1612.	346.	7.68E-09	3.39E-09	8.60	47.	1.60	0.	8.	93.	9185.	1.75E+02	8.81E-05	9.61E-03	-4.29E-09	5.09E-04	0.
1625.	346.	7.66E-09	3.38E-09	8.56	47.	1.60	0.	16.	93.	9183.	1.75E+02	8.80E-05	9.61E-03	-4.27E-09	5.09E-04	0.
1637.	346.	7.63E-09	3.37E-09	8.51	47.	1.60	0.	24.	94.	9181.	1.75E+02	8.80E-05	9.61E-03	-4.25E-09	5.09E-04	0.
1650.	346.	7.60E-09	3.37E-09	8.47	47.	1.60	0.	32.	94.	9179.	1.75E+02	8.80E-05	9.60E-03	-4.24E-09	5.08E-04	0.
1662.	345.	7.58E-09	3.36E-09	8.43	47.	1.60	0.	39.	94.	9176.	1.75E+02	8.79E-05	9.60E-03	-4.22E-09	5.08E-04	0.
1675.	345.	7.55E-09	3.35E-09	8.39	47.	1.60	0.	47.	94.	9174.	1.75E+02	8.79E-05	9.59E-03	-4.20E-09	5.08E-04	0.
1687.	345.	7.52E-09	3.34E-09	8.35	47.	1.60	0.	55.	94.	9172.	1.75E+02	8.78E-05	9.59E-03	-4.18E-09	5.08E-04	0.
1700.	345.	7.50E-09	3.34E-09	8.31	47.	1.60	0.	0.	94.	9170.	1.75E+02	8.78E-05	9.59E-03	-4.16E-09	5.08E-04	0.
1712.	345.	7.47E-09	3.32E-09	8.28	47.	1.60	0.	8.	94.	9166.	1.75E+02	8.77E-05	9.58E-03	-4.15E-09	5.07E-04	0.
1725.	345.	7.44E-09	3.30E-09	8.25	47.	1.60	0.	16.	94.	9162.	1.75E+02	8.77E-05	9.57E-03	-4.14E-09	5.07E-04	0.
1737.	344.	7.42E-09	3.29E-09	8.22	47.	1.60	0.	24.	94.	9157.	1.75E+02	8.76E-05	9.56E-03	-4.13E-09	5.06E-04	0.
1750.	344.	7.39E-09	3.27E-09	8.20	47.	1.60	0.	32.	94.	9153.	1.75E+02	8.75E-05	9.56E-03	-4.12E-09	5.06E-04	0.
1762.	344.	7.36E-09	3.26E-09	8.17	47.	1.60	0.	39.	94.	9149.	1.75E+02	8.74E-05	9.55E-03	-4.11E-09	5.06E-04	0.
1775.	343.	7.34E-09	3.24E-09	8.14	47.	1.60	0.	47.	95.	9145.	1.75E+02	8.74E-05	9.54E-03	-4.10E-09	5.05E-04	0.
1787.	343.	7.31E-09	3.23E-09	8.11	47.	1.60	0.	55.	95.	9140.	1.75E+02	8.73E-05	9.53E-03	-4.09E-09	5.05E-04	0.
1800.	343.	7.29E-09	3.21E-09	8.08	47.	1.60	0.	0.	95.	9136.	1.75E+02	8.72E-05	9.52E-03	-4.08E-09	5.05E-04	0.
1812.	343.	7.26E-09	3.20E-09	8.05	47.	1.60	0.	8.	95.	9134.	1.75E+02	8.72E-05	9.52E-03	-4.06E-09	5.04E-04	0.
1825.	343.	7.24E-09	3.20E-09	8.01	47.	1.60	0.	16.	95.	9132.	1.75E+02	8.71E-05	9.52E-03	-4.04E-09	5.04E-04	0.
1837.	343.	7.21E-09	3.19E-09	7.97	47.	1.60	0.	24.	95.	9130.	1.75E+02	8.71E-05	9.51E-03	-4.02E-09	5.04E-04	0.
1850.	343.	7.19E-09	3.18E-09	7.93	47.	1.60	0.	32.	95.	9128.	1.75E+02	8.70E-05	9.51E-03	-4.00E-09	5.04E-04	0.
1862.	342.	7.16E-09	3.17E-09	7.89	47.	1.60	0.	39.	95.	9125.	1.75E+02	8.70E-05	9.50E-03	-3.99E-09	5.04E-04	0.
1875.	342.	7.14E-09	3.17E-09	7.85	47.	1.60	0.	47.	95.	9123.	1.75E+02	8.70E-05	9.50E-03	-3.97E-09	5.03E-04	0.
1887.	342.	7.11E-09	3.16E-09	7.82	47.	1.60	0.	55.	95.	9121.	1.75E+02	8.69E-05	9.50E-03	-3.95E-09	5.03E-04	0.
1900.	342.	7.00E-09	3.15E-09	6.44	28.	3.25	2.50	1.	95.	2537.	6.78E+01	8.69E-05	7.85E-03	-3.93E-09	1.50E-03	0.
1912.	343.	7.02E-09	3.23E-09	5.44	28.	3.25	2.50	17.	95.	2544.	5.93E+01	8.73E-05	6.90E-03	-3.78E-09	1.31E-03	0.
1925.	345.	6.96E-09	3.32E-09	5.12	28.	3.25	2.50	34.	94.	2550.	5.78E+01	8.77E-05	6.76E-03	-3.64E-09	1.29E-03	0.
1937.	346.	6.90E-09	3.41E-09	4.88	28.	3.25	2.50	51.	93.	2557.	5.78E+01	8.82E-05	6.70E-03	-3.50E-09	1.27E-03	0.
1950.	348.	6.85E-09	3.49E-09	4.66	28.	3.25	2.50	67.	93.	2563.	5.65E+01	8.86E-05	6.68E-03	-3.35E-09	1.27E-03	0.
1962.	349.	6.80E-09	3.58E-09	4.46	28.	3.25	2.50	84.	92.	2570.	5.62E+01	8.90E-05	6.67E-03	-3.21E-09	1.27E-03	0.
1975.	350.	6.75E-09	3.68E-09	4.27	28.	3.25	2.50	101.	91.	2576.	5.60E+01	8.94E-05	6.60E-03	-3.07E-09	1.27E-03	0.
1987.	352.	6.70E-09	3.77E-09	4.08	28.	3.25	2.50	117.	91.	2583.	5.59E+01	8.98E-05	6.69E-03	-2.93E-09	1.27E-03	0.
2000.	353.	6.65E-09	3.87E-09	3.90	28.	3.25	2.50	133.	90.	2589.	5.58E+01	9.03E-05	6.71E-03	-2.79E-09	1.28E-03	0.
2012.	354.	6.61E-09	3.96E-09	3.71	28.	3.25	2.50	150.	89.	2596.	5.57E+01	9.07E-05	6.74E-03	-2.64E-09	1.28E-03	0.
2025.	356.	6.57E-09	4.06E-09	3.53	28.	3.25	2.50	167.	89.	2602.	5.57E+01	9.11E-05	6.76E-03	-2.50E-09	1.28E-03	0.
2037.	357.	6.53E-09	4.17E-09	3.34	28.	3.25	2.50	183.	88.	2609.	5.57E+01	9.15E-05	6.80E-03	-2.36E-09	1.29E-03	0.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2062.	360.	6.46E-09	4.30E-09	2.97	28.	3.25	2.50	217.	87.	2622.	5.57E+01	9.24E-05	6.06E-03	-2.08E-09	1.30E-03	0.
2075.	361.	6.42E-09	4.49E-09	2.79	28.	3.25	2.50	233.	86.	2628.	5.57E+01	9.28E-05	6.90E-03	-1.94E-09	1.31E-03	0.
2087.	363.	6.39E-09	4.60E-09	2.60	28.	3.25	2.50	250.	86.	2635.	5.58E+01	9.33E-05	6.94E-03	-1.80E-09	1.32E-03	0.
2100.	364.	6.36E-09	4.71E-09	2.41	28.	3.25	2.50	267.	85.	2641.	5.58E+01	9.37E-05	6.97E-03	-1.66E-09	1.32E-03	0.
2112.	365.	6.34E-09	4.83E-09	2.20	28.	3.25	2.50	283.	85.	2648.	5.59E+01	9.42E-05	7.02E-03	-1.50E-09	1.33E-03	0.
2125.	367.	6.31E-09	4.96E-09	1.99	28.	3.25	2.50	300.	84.	2655.	5.60E+01	9.46E-05	7.06E-03	-1.35E-09	1.34E-03	0.
2137.	368.	6.29E-09	5.09E-09	1.78	28.	3.25	2.50	317.	83.	2662.	5.61E+01	9.51E-05	7.11E-03	-1.20E-09	1.35E-03	0.
2150.	370.	6.27E-09	5.23E-09	1.56	28.	3.25	2.50	333.	83.	2670.	5.61E+01	9.56E-05	7.15E-03	-1.05E-09	1.35E-03	0.
2162.	371.	6.26E-09	5.37E-09	1.34	28.	3.25	2.50	350.	82.	2677.	5.62E+01	9.61E-05	7.20E-03	-8.92E-10	1.36E-03	0.
2175.	373.	6.24E-09	5.51E-09	1.12	28.	3.25	2.50	367.	82.	2684.	5.63E+01	9.65E-05	7.25E-03	-7.39E-10	1.37E-03	0.
2187.	375.	6.23E-09	5.65E-09	0.89	28.	3.25	2.50	383.	81.	2691.	5.64E+01	9.70E-05	7.29E-03	-5.84E-10	1.38E-03	0.
2200.	376.	6.22E-09	5.79E-09	0.66	28.	3.25	2.50	400.	80.	2698.	5.65E+01	9.75E-05	7.34E-03	-4.30E-10	1.39E-03	0.
2212.	377.	6.22E-09	5.93E-09	0.44	28.	3.25	2.50	417.	80.	2704.	5.66E+01	9.79E-05	7.38E-03	-2.87E-10	1.40E-03	0.
2225.	379.	6.21E-09	6.07E-09	0.22	28.	3.25	2.50	433.	79.	2711.	5.66E+01	9.84E-05	7.43E-03	-1.44E-10	1.40E-03	0.
2237.	380.	6.21E-09	6.21E-09	0.00	28.	3.25	2.50	450.	79.	2717.	5.67E+01	9.88E-05	7.47E-03	-9.77E-13	1.41E-03	0.
2250.	382.	6.19E-09	6.36E-09	1.78	28.	3.25	2.50	467.	78.	2723.	5.68E+01	9.93E-05	7.52E-03	-1.14E-09	1.42E-03	0.
2262.	383.	6.17E-09	6.50E-09	1.57	28.	3.25	2.50	483.	78.	2730.	5.69E+01	9.97E-05	7.56E-03	-1.00E-09	1.43E-03	0.
2275.	384.	6.16E-09	6.65E-09	1.37	28.	3.25	2.50	500.	77.	2736.	5.69E+01	1.00E-04	7.60E-03	-8.64E-10	1.44E-03	0.
2287.	386.	6.14E-09	6.81E-09	1.16	28.	3.25	2.50	517.	77.	2743.	5.70E+01	1.01E-04	7.65E-03	-7.28E-10	1.44E-03	0.
2300.	387.	6.13E-09	6.96E-09	0.95	28.	3.25	2.50	533.	76.	2749.	5.71E+01	1.01E-04	7.69E-03	-5.92E-10	1.45E-03	0.
2312.	388.	6.12E-09	7.12E-09	0.74	28.	3.25	2.50	550.	76.	2755.	5.72E+01	1.01E-04	7.74E-03	-4.57E-10	1.46E-03	0.
2325.	390.	6.11E-09	7.28E-09	0.52	28.	3.25	2.50	567.	75.	2762.	5.72E+01	1.02E-04	7.78E-03	-3.21E-10	1.47E-03	0.
2337.	391.	6.11E-09	7.45E-09	0.30	28.	3.25	2.50	583.	75.	2768.	5.73E+01	1.02E-04	7.82E-03	-1.86E-10	1.47E-03	0.
2350.	393.	6.11E-09	7.61E-09	0.08	28.	3.25	2.50	600.	74.	2775.	5.74E+01	1.03E-04	7.87E-03	-5.05E-11	1.48E-03	0.
2362.	394.	6.11E-09	7.78E-09	-0.14	28.	3.25	2.50	617.	74.	2781.	5.75E+01	1.03E-04	7.91E-03	8.48E-11	1.49E-03	0.
2375.	395.	6.11E-09	7.96E-09	-0.36	28.	3.25	2.50	633.	73.	2788.	5.75E+01	1.04E-04	7.96E-03	2.20E-10	1.50E-03	0.
2387.	397.	6.11E-09	8.13E-09	-0.59	28.	3.25	2.50	650.	73.	2794.	5.76E+01	1.04E-04	8.00E-03	3.55E-10	1.51E-03	0.
2400.	398.	6.12E-09	8.31E-09	-0.82	28.	3.25	2.50	667.	73.	2800.	5.77E+01	1.05E-04	8.04E-03	4.90E-10	1.51E-03	0.
2412.	400.	6.13E-09	8.51E-09	-1.08	28.	3.25	2.50	683.	72.	2807.	5.77E+01	1.05E-04	8.09E-03	6.38E-10	1.52E-03	0.
2425.	401.	6.15E-09	8.72E-09	-1.33	28.	3.25	2.50	700.	72.	2814.	5.78E+01	1.06E-04	8.14E-03	7.87E-10	1.53E-03	0.
2437.	403.	6.16E-09	8.92E-09	-1.60	28.	3.25	2.50	717.	71.	2821.	5.79E+01	1.06E-04	8.19E-03	9.36E-10	1.54E-03	0.
2450.	404.	6.18E-09	9.14E-09	-1.86	28.	3.25	2.50	733.	71.	2828.	5.80E+01	1.07E-04	8.24E-03	1.08E-09	1.55E-03	0.
2462.	406.	6.21E-09	9.35E-09	-2.13	28.	3.25	2.50	750.	70.	2835.	5.80E+01	1.07E-04	8.29E-03	1.23E-09	1.56E-03	0.
2475.	407.	6.23E-09	9.57E-09	-2.40	28.	3.25	2.50	767.	70.	2842.	5.81E+01	1.08E-04	8.33E-03	1.38E-09	1.57E-03	0.
2487.	409.	6.26E-09	9.80E-09	-2.68	28.	3.25	2.50	783.	69.	2849.	5.81E+01	1.08E-04	8.38E-03	1.53E-09	1.57E-03	0.
2500.	410.	6.29E-09	1.00E-08	-2.95	28.	3.25	2.50	800.	69.	2856.	5.82E+01	1.09E-04	8.43E-03	1.68E-09	1.58E-03	0.
2512.	411.	6.33E-09	1.02E-08	-3.21	28.	3.25	2.50	817.	68.	2862.	5.83E+01	1.09E-04	8.47E-03	1.82E-09	1.59E-03	0.
2525.	413.	6.36E-09	1.05E-08	-3.46	28.	3.25	2.50	833.	68.	2869.	5.83E+01	1.10E-04	8.52E-03	1.95E-09	1.60E-03	0.
2537.	414.	6.40E-09	1.07E-08	-3.72	28.	3.25	2.50	850.	67.	2875.	5.84E+01	1.10E-04	8.56E-03	2.09E-09	1.61E-03	0.
2550.	415.	6.45E-09	1.09E-08	-3.98	28.	3.25	2.50	867.	67.	2881.	5.84E+01	1.10E-04	8.61E-03	2.22E-09	1.61E-03	0.
2562.	417.	6.49E-09	1.11E-08	-4.25	28.	3.25	2.50	883.	67.	2888.	5.85E+01	1.11E-04	8.65E-03	2.36E-09	1.62E-03	0.
2575.	418.	6.54E-09	1.14E-08	-4.51	28.	3.25	2.50	900.	66.	2894.	5.85E+01	1.11E-04	8.69E-03	2.49E-09	1.63E-03	0.
2587.	420.	6.60E-09	1.16E-08	-4.78	28.	3.25	2.50	917.	66.	2900.	5.86E+01	1.12E-04	8.74E-03	2.63E-09	1.64E-03	0.
2600.	421.	6.65E-09	1.18E-08	-5.05	28.	3.25	2.50	933.	65.	2907.	5.86E+01	1.12E-04	8.78E-03	2.76E-09	1.65E-03	0.
2612.	422.	6.71E-09	1.21E-08	-5.29	28.	3.25	2.50	950.	65.	2913.	5.87E+01	1.13E-04	8.82E-03	2.88E-09	1.65E-03	0.
2625.	424.	6.77E-09	1.23E-08	-5.53	28.	3.25	2.50	967.	65.	2918.	5.87E+01	1.13E-04	8.86E-03	3.00E-09	1.66E-03	0.
2637.	425.	6.83E-09	1.25E-08	-5.77	28.	3.25	2.50	983.	64.	2924.	5.87E+01	1.14E-04	8.90E-03	3.11E-09	1.67E-03	0.
2650.	426.	6.90E-09	1.27E-08	-6.02	28.	3.25	2.50	1000.	64.	2930.	5.88E+01	1.14E-04	8.94E-03	3.23E-09	1.67E-03	0.
2662.	427.	6.97E-09	1.30E-08	-6.26	29.	3.25	2.50	1017.	64.	2936.	5.88E+01	1.14E-04	8.98E-03	3.35E-09	1.68E-03	0.
2675.	428.	7.04E-09	1.32E-08	-6.51	29.	3.25	2.50	1033.	63.	2941.	5.88E+01	1.15E-04	9.02E-03	3.47E-09	1.69E-03	0.
2687.	430.	7.11E-09	1.35E-08	-6.76	29.	3.25	2.50	1050.	63.	2947.	5.89E+01	1.15E-04	9.05E-03	3.59E-09	1.69E-03	0.
2700.	431.	7.19E-09	1.37E-08	-9.57	48.	1.60	0.	0.	63.	10612.	1.72E+02	1.16E-04	1.24E-02	3.70E-09	6.46E-04	0.
2712.	431.	7.22E-09	1.37E-08	-9.50	48.	1.60	0.	0.	63.	10612.	1.72E+02	1.16E-04	1.24E-02	3.67E-09	6.46E-04	0.
2725.	431.	7.25E-09	1.37E-08	-9.42	48.	1.60	0.	16.	63.	10612.	1.72E+02	1.16E-04	1.24E-02	3.64E-09	6.46E-04	0.
2737.	431.	7.28E-09	1.37E-08	-9.35	48.	1.60	0.	24.	63.	10612.	1.72E+02	1.16E-04	1.24E-02	3.62E-09	6.46E-04	0.
2750.	431.	7.31E-09	1.37E-08	-9.27	48.	1.60	0.	32.	63.	10612.	1.72E+02	1.16E-04	1.24E-02	3.59E-09	6.46E-04	0.
2762.	431.	7.34E-09	1.37E-08	-9.20	48.	1.60	0.	39.	63.	10612.	1.72E+02	1.16E-04	1.24E-02	3.56E-09	6.46E-04	0.
2775.	431.	7.37E-09	1.37E-08	-9.12	48.	1.60	0.	47.	63.	10612.	1.72E+02	1.16E-04	1.24E-02	3.53E-09	6.46E-04	0.
2787.	431.	7.39E-09	1.37E-08	-9.05	48.	1.60	0.	55.	63.	10612.	1.72E+02	1.16E-04	1.24E-02	3.50E-09	6.46E-04	0.

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2000. 431. 7.42E-09 1.37E-08 -0.98  48. 1.60 0.      0.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.47E-09 6.46E-04  0.
2912. 431. 7.45E-09 1.37E-08 -0.91  48. 1.60 0.      8.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.44E-09 6.46E-04  0.
2025. 431. 7.48E-09 1.37E-08 -0.83  48. 1.60 0.     16.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.42E-09 6.46E-04  0.
2037. 431. 7.51E-09 1.37E-08 -0.76  48. 1.60 0.     24.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.39E-09 6.46E-04  0.
2050. 431. 7.53E-09 1.37E-08 -0.69  48. 1.60 0.     32.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.36E-09 6.46E-04  0.
2862. 431. 7.56E-09 1.37E-08 -0.62  48. 1.60 0.     39.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.34E-09 6.46E-04  0.
2875. 431. 7.59E-09 1.37E-08 -0.55  48. 1.60 0.     47.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.31E-09 6.46E-04  0.
2887. 431. 7.61E-09 1.37E-08 -0.48  48. 1.60 0.     55.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.28E-09 6.46E-04  0.
2900. 431. 7.64E-09 1.37E-08 -0.42  48. 1.60 0.      0.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.26E-09 6.46E-04  0.
2912. 431. 7.67E-09 1.37E-08 -0.35  48. 1.60 0.      0.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.23E-09 6.46E-04  0.
2925. 431. 7.69E-09 1.37E-08 -0.28  48. 1.60 0.     16.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.20E-09 6.46E-04  0.
2937. 431. 7.72E-09 1.37E-08 -0.22  48. 1.60 0.     24.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.18E-09 6.46E-04  0.
2950. 431. 7.74E-09 1.37E-08 -0.15  48. 1.60 0.     32.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.15E-09 6.46E-04  0.
2957. 431. 7.76E-09 1.37E-08 -0.11  48. 1.60 0.     36.  63. 10612. 1.72E+02 1.16E-04 1.24E-02 3.14E-09 6.46E-04  0.
PARAMETER ESTIMATES AND SUM SQRS DEVS, ITERATION *   1(  20)
  -1.72000E+01     3.23395E-20

 LAMTUR--2(-2 IS .5, -3 IS .333 POWER OF VEL/X)
LOOP/RUN * 1  HOT ZONE EXP; THEORY FLUXES.
 AVERAGE DEVIATION OF THEORY FROM EXPERIMENT =  *.%.
  -5.25E-12    -3.50E-12    -3.25E-12    -4.46E-12    0.
  -5.08E-11    -4.05E-11    -3.40E-11    -4.91E-11    0.

 LAMTUR--2(-2 IS .5, -3 IS .333 POWER OF VEL/X)
LOOP/RUN * 2  HOT ZONE EXP; THEORY FLUXES.
 AVERAGE DEVIATION OF THEORY FROM EXPERIMENT =  *.%.
  -1.80E-11    -1.42E-11    -1.47E-11    -1.76E-11    0.
  -1.10E-10    -7.56E-11    -6.40E-11    -9.22E-11    0.

 LAMTUR--2(-2 IS .5, -3 IS .333 POWER OF VEL/X)
LOOP/RUN * 3  HOT ZONE EXP; THEORY FLUXES.
 AVERAGE DEVIATION OF THEORY FROM EXPERIMENT =  *.%.
  -1.60E-12    -9.94E-13    -1.22E-12    -1.41E-12    0.
  -4.64E-11    -3.20E-11    -2.60E-11    -3.00E-11    0.
  ****************************************************FLUXES ARE IN MOLES/SEC/CM2
    FOR LAMINAR, L/D=-2,(NEGATIVE IS AUTO).


      0.       -0.       0.   0.   0.       0. 2-2 0 4 0 1 310102345 2-0
                                               T D LTFELHIWNIN2ACITRLRHNU
     -0.       -0.      -0.  -0.  -0.      -0.-0-0-0-0-0-0-0-0-0-0-0-0-0-0
```

SUMMARY OF FLUXES PREDICTED BY MODEL, USING 1/2 POWER VELOCITY DEPENDENCE IN THE COUPON ZONE; ASSUMING FLUID DIFFUSION ALONE CONTROLS, NO PARTICLES IN THE LITHIUM. See Chapter V.

APPENDIX V. Subroutines SUPER

Superposition subroutines for substitution into program METAL in order to solve differential equation by superposition around entire loop. rather than only in test zones.

Replace subroutine CRUNCH with these subroutines.

THESE SUBROUTINES MAY REQUIRE modification in order to work properly with program METAL.

```
      SUBROUTINE SUPERP
C
C
      INTEGER DOPT,TOPT
      DIMENSION AREAD(20),A(20,5),A0(20,5)
      COMMON/D/FLUX,SOL,ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,NIKIRN,
     +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
     +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI,Y2,AINC,
     +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
     +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,DELC,XLD,DIFF,RNUSS,KMASS,
     +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,
     +A2133,ZSTEP,ZETSTP,WTHICK,BPOWER,REALK,DENS
      DIMENSION PDXO(20),PDX(20),SQPAR(2,20),PMOVE(20),Y(5),YPRIME(5)
      ITERS=0
      Y(1)=YI
      YO=YI
      CALL SUPER1(Y,0)
      DEL=Y(1)-YO
C     HOW FAR OFF IS MASS BALANCE?
C     SAVE THIS CURRENT VALUE (LAST VALUE) OF YO, USE NEW VALUE
      YLAST=YO
      YO=YO+AINC
      Y(1)=YO
    1 ITER=ITER+1
      ITERS=ITERS+1
      IF(ITERS.GT.10)CALL SUPER1(Y,1)
      IF(ITERS.GT.10)WRITE(6,3)
    3 FORMAT(" MASS BALANCE DOESN'T CLOSE AFTER 10 ITERATIONS",/,
     +" PROGRAM WILL STOP. CHECK YOUR NUMBERS")
      IF(ITERS.GT.10)CALL QUIT(1)
C
    2 CALL SUPER1(Y,0)
C     DEL1 IS MASS IMBALANCE, YMOVE IS SECANT ITERATION MOVE
C     YD IS NEW BEST GUESS ON CONCENTRATION
C     SAVE YLAST AND THIS DEL FOR NEXT ITERATION, RESET YO AND Y(1)
      DEL1=Y(1)-YO
      IF(ABS(DEL1).LE.EPSLIM.AND.NNLAST.EQ.1)CALL SUPER1(Y,1)
      IF(ABS(DEL1).LE.EPSLIM)GO TO 38
      IF(DEL.EQ.DEL1)GO TO 34
      YMOVE=DEL1*((YLAST-YO)/(DEL-DEL1))
   34 YD=YO-YMOVE
      AINC=YD/100.
      YLAST=YO
      DEL=DEL1
      YO=YD
      Y(1)=YD
      IF(ABS(DEL).GT.EPSLIM)GO TO 1
   38 CONTINUE
   43 ITLAST=0
      YI=Y(1)
      RETURN
      END
C
C
      SUBROUTINE SUPER1(Y,IWR)
      INTEGER DOPT,TOPT
      DIMENSION AREAD(20),A(20,5),A0(20,5)
      COMMON/D/FLUX,SOL,ISECT,A,DIAM,T,TOPT,DOPT,DX,LNUM,LAMTUR,NIKIRN,
     +IL,IWT,SCHM,REYN,P,DIAA,TC,VEL,VM,ISPLIT,FSPLIT(5,5),XSPLIT(5,5),
     +XTEST(2,5,5),FLXTHY(2,5,5),EPSLIM,FLXEXP(2,5,5),N1,N2,YI,Y2,AINC,
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         +NNLAST,ALN186,ALN26,CUTL,CUTH,CUTLL,CUTHL,IXL,DIAML,IFLD,IHAUSN,
         +ITER,IPAK1(100),RLAM,DMD,IFLXX,TERM,DELC,XLD,DIFF,RNUSS,KMASS,
         +IPAK2(100),PRNDTL,QLOSS0,THRMSS,THRMLI,TSTNBY,DPDX,
         +A2133,ZSTEP,ZETSTP,WTHICK,BPOWER,REALK,DENS
          DIMENSION PDXO(20),PDX(20),SQPAR(2,20),PMOVE(20),Y(5),YPRIME(5)
          DIMENSION ZSPLIT(5,6)
          DATA ZSPLIT/5*0.,5*1500.,5*2300.,5*2600.,5*2800.,5*3000./
          DATA XSHIFT/400./

  2       YEND=0.
          ISPLIT=0
          ISECT=5
          YMVLST=YI
  3       ISPLIT=ISPLIT+1
          IF(ISPLIT.EQ.1.AND.IWR.EQ.1)WRITE(6,53)Y(1)
          IF(ISPLIT.EQ.5)YMV5=YMVE
          IF(ISPLIT.EQ.5)ISECT=0
  5       IF(ISECT.EQ.4)Y(1)=SOL-YEND
          IF(ISECT.EQ.4)GO TO 100
          IF(ISPLIT.EQ.5)ISECT=ISECT+1
          IF(ISPLIT.EQ.5)YMVLST=YMV5
          ZSTART=ZSPLIT(1,ISPLIT)
          Z=ZSTART
  C       SET BEGINNING OF THIS SUPERPOSITION SECTION
  C       STEP AHEAD. SET END POINT OF THIS SOLUTION STEP.
  C
  C
  7       Z=Z+ZSTEP
          IF(Z.GT.ZSPLIT(1,ISPLIT+1).AND.
         +ISECT.NE.5.AND.ISPLIT.EQ.5)GO TO 5
  C       RESET CONCENTRATION TO OUTLET VALUE OF THIS STAGE OF THE SUPERPOSITION
          IF(Z.GT.ZSPLIT(1,ISPLIT+1))Y(1)=YMVE
          IF(Z.GT.ZSPLIT(1,ISPLIT+1))GO TO 3
          ZETA=0.
          ZEND=Z
          XSTART=ZSTART+XSHIFT
          IF(XSTART.GE.A(5,LNUM))XSTART=XSTART-A(5,LNUM)
          Y(2)=1.
          N=1
  C       GET FLOW PROPERTIES FROM SUBROUTINE FCN
          CALL FCN(Y,XSTART,N,YPRIME)
          RYNPOW=REALK/REYN**(1./BPOWER)
          CJ=.026**(1.-RYNPOW)*(1.62**RYNPOW)
          EJ=(-.2-.4666*RYNPOW)
          SOL1=SOL
          DIAZ=DMD
  C
  C

          OFFSET=SOL-Y(1)
          ZLEFT=ZEND-ZSTART
  C       SOLUTION FOR SINGLE STEP CHANGE IN WALL POTENTIAL
          OFFSET=OFFSET*EXP(-4./SCHM**.6666*CJ*REYN**EJ*
         +(ZLEFT/DIAZ)**(1.-REALK/3./REYN**(1./BPOWER)))
  C
  C       ZETSTP IS SMALL STEP TAKEN IN SUPERPOSITION SOLUTION TO FIND
  C       THE SOLUTION AT POINT Z.
  C       THE X COORDINATE IS FROM THE PROPERTIES SUBROUTINE, STARTS UPSTREAM
  C       OF HEATER.  THE Z COORDINATES OF SUPERPOSITION START DOWNSTREAM OF
  C       OF TEST SECTIONS.
  10      ZETA=ZETA+ZETSTP
```

```
        XMOVE=ZETA+ZSTART+XSHIFT
        IF(XMOVE.GE.A(5,LNUM))XMOVE=XMOVE-A(5,LNUM)
        IF(ZETA+ZSTART.GT.ZEND)GO TO 50
        CALL SOLBIL(XMOVE)
        DCZET=SOL-SOL1
        SOL1=SOL
        ZLEFT=ZEND-ZSTART-ZETA
C       SUPERPOSITION OF SMALL INCREMENTAL CHANGES IN WALL POTENTIAL
        ADDEND=DCZET*EXP(-4./SCHM**.6666*CJ*REYN**EJ*
       +(ZLEFT/DIAZ)**(1.-REALK/3./REYN**(1./BPOWER)))
        OFFSET=OFFSET+ADDEND
        GO TO 10
C       CONCENTRATION AT CURRENT POINT IS SOLUBILITY-OFFSET
 50     YMVE=SOL-OFFSET
        FLOW=A(7,LNUM)*FSPLIT(ISECT,LNUM)
        SUPFLX=(YMVLST-YMVE)*FLOW/DENS/(3.14159*DIAZ*ZSTEP)
        YMVLST=YMVE
        IF(IWR.EQ.1)
       +WRITE(6,51)ISPLIT,ISECT,ZEND,XMOVE,SOL,OFFSET,YMVE,SUPFLX
 51     FORMAT(1X,I1,",",I1,". Z= ",F5.0," X= ",F5.0,"S=",E10.3,
       +", O=",E10.3," C=",E10.3," N=",E10.3)
 53     FORMAT("  INITIAL CONCENTRATION =",E10.3)
C       AFTER PARALLEL SECTION (ISECT =1,2,3,OR 4) FLOW-AVERAGE THE OUTLET
        IF(ISECT.NE.5.AND.ZEND.EQ.ZSPLIT(1,6))             CONCENTRATION
       +YEND=YEND+OFFSET*FSPLIT(ISECT,LNUM)
C       STORE "THEORETICAL" FLUX AT  COUPONS AS FOUND BY SUPERPOSITION.
        IF(ZEND.EQ.(2800.+ZSTEP))FLXTHY(1,ISECT,LNUM)=SUPFLX
        GO TO 7
 100    IF(IWR.EQ.1)
       +WRITE(6,52)LNUM,((FLXEXP(IFL,IJL,LNUM),IJL=1,5),IFL=1,2),Y(1)
 52     FORMAT(" ACTUAL FLUXES FOR LOOP #",I2,/,5E15.3,/,5E15.3,
       +/," CONC MIX AT END =",E15.3)
        RETURN
        END
```

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