Westinghouse Electric Corporation
Energy Systems

Nuclear and Advanced Technology Division

Box 355
Pittsburgh Pennsylvania 15230-0355

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Docket No.: STN-52-003

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: MR. R. W. BORCHARDT

SUBJECT: RESPONSE TO INEL REQUEST FOR SPES-2 INFORMATION/ CLARIFICATION - MGO-29-93

Dear Mr. Borchardt:

This letter responds to a request for information on the AP600 SPES-2 test facility received in a letter dated June 28, 1993 from Mr. Ortiz of the Idaho National Engineering Laboratory (INEL). Attachment 1 provides written responses to the information requested by INEL. Attachment 2 identifies two reports prepared by SIET for the SPES facility which provide supplemental data requested by INEL. These reports are provided as an enclosure to this letter.

The Westinghouse Electric Corporation copyright notice is also attached.

Please contact Brian A. McIntyre on (412) 374-4334 if you have any questions concerning this transmittal.

N. J. Liparulo, Manager
Nuclear Safety & Regulatory Activities

/

Enclosures
Attachments

cc: T. Kenyon, NRC (w/o enclosures/attachments)
R. Hasselberg, NRC (3 copies enclosures/ 1 copy attachments)
M. G. Ortiz, INEL (1 copy enclosures/attachments)
B. A. McIntyre, Westinghouse (w/o enclosures/attachments)

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Attachment 1 to Westinghouse Letter ET-NRC-93-3943
Response to INEL Request for SPES-2 Information/Clarification - MGO-29-93
M. G. Ortiz to L. E. Conway, dated June 28, 1993

1. Electrically Powered Rods

In response to previous questions posed to the NRC we received References 9, 11, and 20, each of which contains some information about the power channel. We still have some questions.

1.1 What is the heat flux of the "hot" rods and the "standard" rods?

Reference 19, pg. 6 gives the total power as 9MW distributed uniformly in the axial direction. Reference 11, Figure 3.3.2/1 shows the dimensions for a "hot" and "standard" rod. If there are two different rods, we need to know the heat flux through each type of rod.

Response:
The SPES-2 nominal full power will be 4.91 MW. The nominal power for the 95 standard rods is 50.42 kw/rod (4.2 kw/ft) and for the 2 hot rods is 60.0 kw/rod (5 kw/ft).

1.2 There are 97 rods. How many are "hot"? Where are they located in the core?

If there are two types of rods, we may separate the core region into two separate channels. To do this we need to know how many "hot" rods there are and where they are located.

Response:
There are two (2) hot rods in rod positions 39 and 93 as shown in the attached figure.

1.3 Which end of the page of Reference 11, Figure 3.3.2/1 is the top of the fuel rod?

Response:
The end of the rod with the thermocouple leads is the bottom end which extends out of the bottom of the reactor vessel. The top end has a 5mm ϕ, 42 mm long reduced diameter section and a 10 mm long threaded end (shown as 4 mm ϕ).

1.4 What is the configuration of materials used to construct the fuel rod in the heated and unheated portion? Is the nickel 200 portion of the rod solid or tubular? If tubular, what is the wall thickness?

In our copy of Reference 11, Figure 3.3.2/1, it is difficult to determine the configuration of the rod, particularly to what layer of material the material call-outs are pointing to.

Response:
As Figure 3.3.2/1 shows, the rod heated portion is an Inconel 600 hollow tube 3663 mm long (actual heated length is 3660 mm due to transitions at each end). The standard rod tube OD is 9.5 mm and ID is 7.9 mm. The hot rod OD and ID are 9.5 and 7.5 mm, respectively. The nickel 200 portion at the top of the rod is solid. The remaining construction of the rod is, from the bottom:

- hollow copper rod; ID=5.2 mm, OD=8.5 mm; 130 mm long;
- hollow copper rod, as above; with a 0.5 mm thick 316 stainless steel clad; 2275.5 mm long (overall OD=9.5mm);
- hollow copper rod, ID=5.2mm, OD=7mm; with 1.25 mm thick 316 stainless steel clad; (overall OD=9.5 mm); 20 mm long. Note the 1.5 mm transitions shown in the figure.
- heated length, discussed above;
- solid nickel top piece, discussed above.

2. Electric Cable Power Leakage

2.1 What is the justification for the fraction of heat diverted to leakage in Reference 1 and is there any other leakage such as at the rod endpoints that might also be considered?

The electric heaters were modeled in Reference 1 as losing some heat to the vessel lower plenum, which was pointed out in Reference 12 as being due to heating in lower plenum from leakage of power cables.

This may lead to a serious distortion of events in the lower plenum. This heated fluid may flash before the rest of the primary, not only maintaining the system at a higher pressure than expected during depressurization, but also allowing

voids in the fluid before it goes through the core.

Response:
SIET has calculated the heat loss from the rods in the lower plenum to be 1.3% of the rod power. The operating temperature of the lower plenum measured during the SPES steady state, pre-transient, full power condition was ~280°C (536°F), at 0.693 m below the center line of the downcomer entrance into the reactor vessel.

In SPES-2, the fluid volume of the lower plenum is 2.28E-2 m^3. This is the properly scaled volume to simulate the AP600 lower RV head. Therefore, this volume should be maintained at the cold leg temperature. During transients, after reactor trip, the ~1% of decay power into the lower plenum will have no significant impact on the fluid conditions. There are no other significant power losses.

3. Rod Bundle Spacers

3.1 How many rod bundle spacers are there in the power channel, and what is their elevation with respect to the bottom of the active fuel?

Reference 11, Figure 3.3.2/2 illustrates a rod bundle spacer. However, we have no information that specifically shows their location in the power channel.

Response:
There are 11 grid spacers in SPES-2, seven of which are in the heated rod section. The actual, as installed grid locations, referenced from the bottom of the heated portion of the rod to the bottom of the grid are:

3829,3327,2825,2325,1825,1322,827,325,-33,-666, and -1363 mm's.

Attached is a revised drawing of the grid.

4. Lower Core Support Plate

4.1 How many fluid holes are in the lower core support plate and what are their individual diameters?

Reference 11, Figure 3.3.1/6 shows the lower core support plate. This drawing shows several fluid holes. We believe there are holes of three different diameters shown" 10mm, 14mm, and a larger series of holes of unknown diameter. However, the drawing does not state how many holes there are

of each size.

Response:
The figure shows the upper plate from which the SPES-2 rods are hung and there is no "lower" core support plate. The referenced figure states that the flow holes are shown as single circles and the heated rod ends are double circles. The number and size of the flow holes are:

- 152, 7 mm ϕ
- 20, 10 mm ϕ
- 12, 14 mm ϕ

5. Power Channel

5.1 Is the power channel octagonal or cylindrical in shape?

Reference 19, pg. 7 indicates that the "SPES octagonal riser section containing the bundle has been maintained". We have seen no drawings that indicate an octagonally shaped power channel. Was this statement referring to the shape of the rod bundle?

Response:
The power channel is octagonal. The lower plenum is circular in cross section. The octagonal dimensions are shown in Fig. 3.3.1/3 of the SPES Description Report, and are:

- the eight flats are 58.5 mm, and the distance across the octagonal is 141.23 mm.

6. Upper Tie Plate

6.1 Please send a drawing of the upper tie plate showing dimensions and its location in the vessel.

None of our information shows this component.

Response:
See response to item 4.

7. ADS Stages 1-3

7.1 What are the valve opening rates?

Response:
The ADS valve opening times will be ~ 10 seconds.

7.2 Apparently, the valves are oversized and put in series with restricting orifices. The restricting orifices effectively scale the full open area of the valves. Will the rate of area change also be scaled?

<u>Response:</u>
The valves are oversized and therefore the full flow through the orifices will occur in a shorter time.

The ADS areas used for the AP600 plant analyses involving the ADS valves are as follows;

Stage 1	: 2 x 6 in^2 (max)
Stage 2 & 3	: 2 x 28 in^2 (max)
Stage 4	: 1 x 76 in^2 (min)

The max and min refer to the limits defined in GW GL 002 vol 1 rev 0.

For SPES-2 the areas which will be used are:

Stage 1	: 1.960 E-05 m^2
Stage 2 & 3	: 9.144 E-05 m^2
Stage 4	: 33.574 E-05 m^2

Note that Stages 1, 2, and 3 are 1/395 area scale of the AP600; and Stage 4 is oversized.

8. ADS Stage 4

8.1 Has there been a final decision on the size of the ADS stage 4 valve and/or orifice size? If so, what is the size? What is the net area change rate?

Reference 20 indicates some uncertainty as to what the final valve area should be, 3.36e-4 m^2 or 6.84e-4 m^2. Neither of these values is consistent with the orifice size given in Reference 5, pg 46 as 12.48 mm or 1.22e-4 m^2.

<u>Response:</u>
The fourth stage area is given in response to item 7 above. The fourth stage area is expanded as partial compensation for the effects of heat losses.

9. Main Coolant Pumps

9.1 Is the given HAN curve the correct one?
Input for the HAN curve is close to an HAN curve generated from the heat/flow curve, but diverges from HAN curves generated from speed/flow curves.

9.2 What is the reference for the main coolant pump rated head and flow?
The rated head and flow for the main coolant pumps in the updated deck from SIET (Rev 2?) does not agree with any of our references. Our reference 11, pg 2 conflicts with the same reference pg 18.

9.3 What sources were used to develop the remaining six octants of the pump homologous head curves (HAT,HVT,HVR,HAR,HVD,HAD), and the corresponding homologous torque curves?
We have no information for these quadrants of pump operation.

9.4 What sources were used to develop the entire set of homologous two-phase degradation head and torque curves?
We have no information for two-phase degradation of the pump head and torque.

9.5 What sources were used to develop the two-phase multiplier tables?
We have no information for two-phase degradation of the pump head and torque.

Response:
The attached report, SIET - NT/54, "SPES Pump Characterization", forms the basis for two quadrants of the pump performamce curves. Data generated for SEMISCALE tests was used for the remaining quadrants. In the transients represented, the pumps will be turned off early in the test, and will be coasting or free wheeling. In no case will the magnitude of the pump speed be large, and therefore, the kinetic interactions with the fluid will be minimal. Under these conditions, the precise values obtained from the pump curves will have little effect on the transient simulation.

10 Heat Structure

10.1 What are the heat losses of pipes and components to the ambient environment? How were the heat transfer coefficients in Reference 1 developed that model heat losses to the ambient for the cold leg, hot leg, steam generator shell, reactor vessel, etc.?

Response:
The heat losses are evaluated as 110 kW from the primary loop surfaces and 20 kW from each steam generator. This data is based on the SPES-1 tests. The data will be updated, if necessary from the results of the hot shakedown tests.

11. Pressurizer

11.1 Which of the following dimensions correctly describe the current pressurizer in SPES-2 facility?

The following discrepancies were found between References 1,2 and 11. The SPES-2 RELAP5 input deck only gives a cell area and length. From this, the diameter and volume were calculated. The values obtained are from data contained in Components number 360 and 365. See following table.

Pressurizer data discrepancies

	SPES-2 RELAP5 Input Deck[1]	SPES-2: Scaling Update[2], p. 34	SPES-2 Drawing[11] 00189DD92, p. 15.
Diameter [m]	0.13451	0.1345	0.132
Length [m]	6.7855	6.790	6.790
Volume [m^3]	9.6042e-2	9.54e-2	9.292e-2

Response:
The SPES-2, "Scaling Update" pressurizer sizing is correct. The smaller diameter shown on Dwg. 00189DD92, p. 15 was increased to 0.1345 m after the pressurizer was manufactured.

11.2 Is there any pressurizer spray in the SPES-2 facility?

Response:
There will be no pressurizer spray used in SPES-2. The ADS Stage 1 flow path will be used for pressure control prior to transient initiation.

12. Restrictive Orifices

12.1 What are the dimensions, including throat areas, and location of restrictive orifices for the following segments of piping:

- DVI line.
- CMT discharge line.
- Accumulator injection line before DVI line.
- CL orifices between split and connection to the annulus.

The SPES-2 process control diagram (Reference 9, Page 5 of 39) indicates the above orifces but no characteristics are provided for them.

Response:
No flow orifices are currently anticipated in the DVI line, IRWST lines, or in the CMT balance lines. Orifices will be installed as required in the CMT, accumulator, PRHR, and cold legs; in order to closely match the AP600 piping resistances (i.e., k_{AP600} (395^2)).

The actual orifice sizes and overall line losses will be reported upon completion of the cold pre-operational tests and data reduction.

12.2 How many restrictive flow orifices are being used? Please provide a comprehensive list of all restrictive flow orifices, since we are not sure all of them are identified in figures we have received.

Response:
See response to 12.1.

13. Measurement Venturi Tubes And Orifices

13.1 What are the r' or K losses for the venturi tubes and orifices?

Tables 4 and 5 of Reference 10 give some information for these pieces. What are α and α_c? Can the losses such as K (Reference 16) be calculated from these values?

Response:
The venturi tube calibrations will be reported in the SPES-2 facility description report currently being prepared. Note that the venturi losses are included in the actual ΔP measurements discussed in item 12 above. Therefore, analyses can utilize the scaled AP600 line resistances.

14. Steam Generator

14.1 Are there relief valves modeled for the SG or are the ones shown in the overall facility diagrams (Reference 9, Page 5 of 39) only for experiment safety purposes?

Response:
Reference 9, page 5 of 39 shows one spring loaded safety valve on each steam generator. This valve provides overpressure protection. The three valves (2 AOV's, 1 manual) in parallel off the main steam line comprise the SG post-trip heat removal path. The AOV's are used to maintain the SG pressure within ~2 bar of a pre-determined pressure setpoint.

14.2 What are the separator and dryer internal dimensions?

These dimensions cannot be determined from the steam genertor diagram drawings (Reference 9, Page5 of 39) or tabular data from page 7-8 of reference 11.

Response:
For steam generator dimensions, refer to Reference 9, page 14 of 39.

14.3 What is the separator carry under and ΔP?
14.4 What is the pressure drop across the dryer for normal operation?

Response:
No moisture carryover data for SPES-2 is available. The separator and dryer pressure drops measured during SPES operation were ~39 kPa and 5 kPa respectively; at 62 bar and nominal 2.167 MW/SG power level.

14.5 We were told much if not all of the SG data is in an earlier report on SPES. We still do not have any SPES-1 reports. Can you provide them or tell us how to get one?

Response:
Additional steam generator data is contained in the SPES System Description report and the Experimental Data Report for SPES Test SP-SB-04. Both of these SPES reports are provided as an attachment.

15. Emergency Feed Water

15.1 What are the piping dimensions for connections into the feedwater system?
15.2 What is the expected flow rate and fluid pressure and temperature during emergency feed water operation?

Response:
The SPES-2 startup feedwater system will be simulated by the SPES EFWS. The pump used will be a positive displacement pump with a pre-set total pump flow (8 gpm) and a pre-set pump bypass flow. The SFWS will provide:

1.19 gpm/SG at 696 psig

to

0.50 gpm/SG at 1085 psig

The SFWS flow will be automatically turned on/off to control the SG level. The feedwater nozzle (1 1/2 in. Schedule 80) and feedwater ring with "J-tubes", is shown in Reference 9, p. 14 of 39. The actual SFWS piping is not relevant since a positive displacement pump and fixed pump bypass resistance is used.

The expected SFWS water temperature is 30 - 40 °C (water is unheated).

16. IRWST

16.1 What will be the volume and expected initial level during tests?

16.2 What will be the initial conditions for the fluid in IRWST?

16.3 Can the IRWST pressurize, e.g. during long periods of PRHR operation, or is it completely open to the atmosphere?

Response:
The IRWST, as shown in Reference 9, page 18 of 39, is 1.7 m long x 0.386 m wide (cross section area = 0.6562 m^2). The tank will be filled to match the nominal AP600 water level of 28 ft. (8.53 m). The water will be at 20 - 30 °C. The tank is open to the atmosphere and will not pressurize.

17. PRHR

17.1 What are the locations of the split and recombination for the PRHR heat transfer tubes?

Response:
The PRHR piping splits to the individual PRHR just prior to entering and just after exiting the IRWST. The current plan is to use only one of the three available PRHR tubes.

18. Controls, Trips, and Setpoints

18.1 What is the trip and control logic for the following items? Please include the setpoints for:

- Reactor coolant pumps.
- Reactor scram.
- Main feed water.
- Emergency feed water.
- MSIV.
- SI signal actuation settings.
- ADS stage actuation setpoints.

Response:

Reactor trip:	1800 psia (12.41 MPa)
"S" Signal:	1700 psia (11.72 MPa)
Steam generator isolation:	"S" Signal
RCP Trip:	"S" signal plus 16.2 sec
MSIV:	"S" Signal
CMTIV:	"S" Signal

The ADS system actuation is based on the CMT volume as shown below:

Stage	CMT volume (%)
1	75
2	60
3	50
4	20

19. NRHR

19.1 What is the location for connection into the primary system?

19.2 What is the expected flow rate and fluid pressure and temperature during NRHR operation?

Response:

The normal RHR connects to the primary system just upstream of each CMT discharge line orifice location (flanges). This is shown schematically on page 83 of Reference 5.

The NRHR water temperature will be 20 - 30 °C and the expected flow vs. RCS pressure is:

RCS Pressure (bar)	Target Injection rate (kg/s)*	Expected Injection rate (kg/s)
16	0	0.007
12	0	0.073
11	0	0.091
10	0.11	0.110
8.6	0.17	0.138
6.9	0.21	0.154
5.0	0.25	0.224
3.4	0.28	0.273
2.0	0.30	0.326
1.0	0.32	0.377

*This represents flow from 2 AP600 NRHR pumps.

20. MSL

20.1 What are the piping dimensions up to the break location?
20.2 The figure located on Page 5 of 39 from Reference 9 show a relief valve off each steam line. Figure 1 of Reference 10 shows two relief valves. Can we obtain a detailed P&ID for the steam lines or at least identification of valves connected to the steam lines?
20.3 Where in the line are the flow orifices?
20.4 What are the sink conditions for the MSL under normal operation and break circumstances?

Response:
The main steam line as shown in Reference 9, page 14 of 39 is a 3" Schedule 80 pipe. As discussed in item 14 above, one safety valve is provided off each steam line (note: these valves should not operate as they are for pressure protection). The valves simulating the steam generator PORV's are the two parallel AOV's are the two parallel AOV's discussed above. The SPES System Description (attached) provides the MSL piping layout.

The main steam line flow is controlled by a pressure control valve and does not depend on orifices or condenser operating conditions. Note that the MSL is isolated at the start of a transient. The SG PORV's operate on pressure control also. But for simulating the SLB, an orifice will be installed in the PORV line and the PORV's will be opened to simulate the break. Detailed design of the break flow Gamma densitometer, turbine meters, etc. is not complete at this time. The PORV line is piped to one of the break condensers and weigh tank (shared with ADS stage 4).

21. Accumulator

21.1 What will be the initial water level?

Response:
The initial water and gas volume in the accumulator will match the scaled AP600 nominal volumes (i.e., 1700 ft^3/395 water and 300 ft^3/395 gas). The bottom elevation of the accumulator to the DVI in SPES matches AP600. However, the water level in the SPES accumulator (~10 ft. long) will not match the water level in the spherical AP600 accumulator tanks. The water level is not important since the N_2 gas pressure provides the driving head.

22. Accumulator Isolation Valve

22.1 What is the location for the isolation valve?
22.2 What type of valve is this?
22.3 What size is the valve?

Response:
The accumulator isolation valve is a manual, 3/4-in, Y pattern globe valve. It is located near to the accumulator.

23. Operating Data

What will be the steady state conditions for the major components and systems modeled in the SPES-2 facility? The following characteristic operating information obtained from the preliminary tests or known data is needed to enable more accurate representation of component and system pressure losses and flow rates:

23.1 Power including any leakage to facility structure.
23.2 Core inlet temperature.
23.3 Core outlet temperature.
23.4 Primary pressure.
23.5 Pressurizer level.
23.6 Pressurizer heater power (if on).
23.7 Pressurizer spray flow and temperature (if on).
23.8 Core flow.
23.9 Core bypass flow.
23.10 Pump speeds.
23.11 Flow rates through each cold leg and hot leg.
23.12 MCP suction and discharge pressure.
23.13 SG primary inlet pressure.
23.14 Steam generator dome pressures.
23.15 Steam generator pressure at entrance to separator.
23.16 Steam generator feedwater flow rates.

23.17 Steam generator feedwater temperatures.
23.18 Steam generator recirculation ratios.
23.19 Steam generator levels.
23.20 Steam generator sink pressures.
23.21 Any supplemental flow rates and temperatures for letdown, makeup, NRHR, leakage, etc.

Response:
The following table provides the SPES-2 RELAP model initial conditions. The attached table answers most of the data requested. The model does not include many internal details of the steam generators, so items 13, 15,18 and 20 are not known. The coolant pumps operate at 3100 rpm.

Core Power	4.9916 MW
Heat Losses	150 kW *
Vessel Flow	51.26 lbm/sec (23.25 kg/s)
Core Upper Head Bypass Flow	0.419 lbm/sec (0.19 kg/s)
Vessel Inlet Temperature	528.42 deg F (548.95 K)
Vessel Outlet Temperature	599.43 deg F (588.40 K)
Pressurizer Pressure	2250 psia (155.1 bara)
Pressurizer Level	60 %
Steam Generator Pressure	712. psia (49.1 bara)
Steam Generator Level	41.7 ft (12.7 m) **
Feed Water Temperature	439.0 deg F (499.3 K)
Feed Water Flow	2.98 lb/sec (1.35 kg/s)
Accumulator Pressure	700 psia (48.26 bara)
Accumulator Temperature	68 deg F (293.15 K)
Accumulator Water volume	85%
CMT Temperature	68 deg F (293.15 K)

* 110 kW loss on primary, 20 kW each S/G
** Measured from top of tube sheet

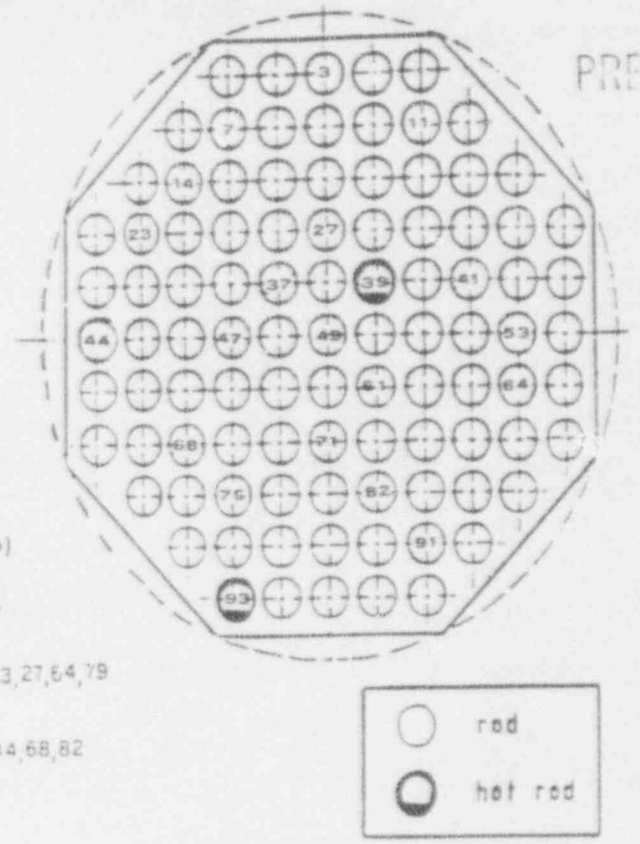
The CVCS flow rate is provided below:

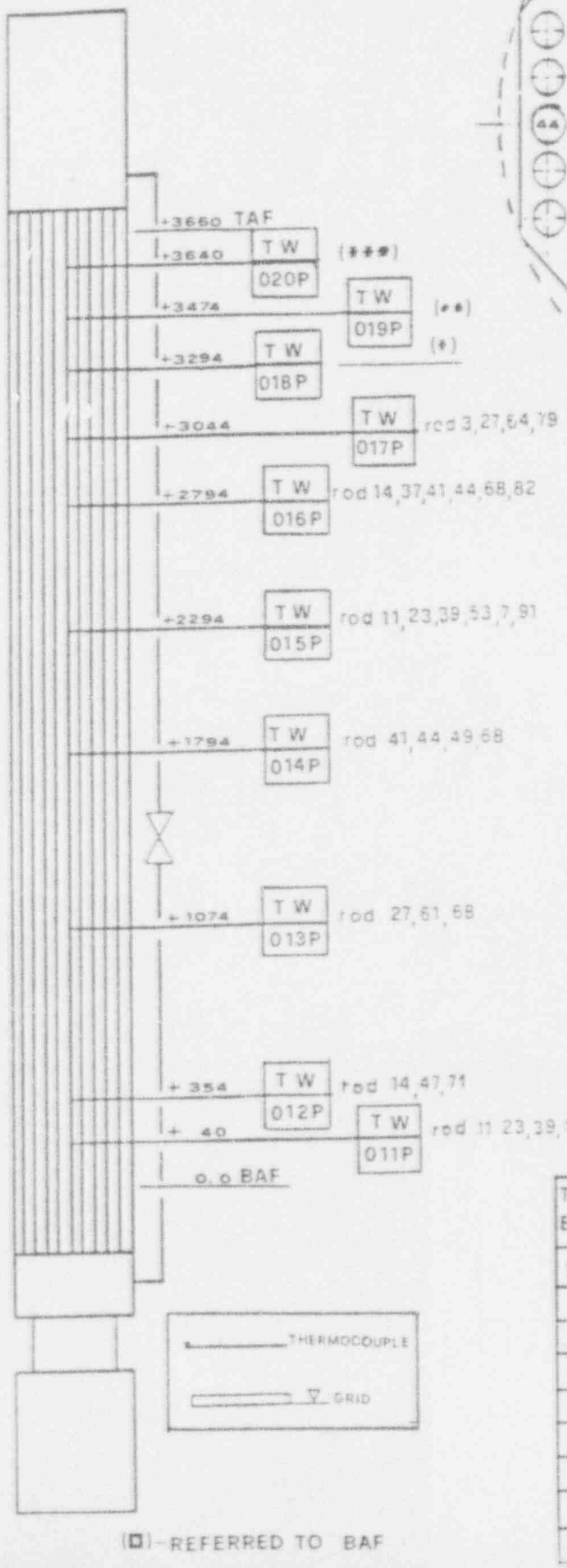
RCS Pressure (Bar)	Target Injection Rate (kg/s)*	Expected Injection Rate (kg/s)
1.	0.080	0.080
34.	0.067	0.070
69.	0.056	0.060
103.	0.048	0.050
138.	0.040	0.040
155.	0.034	0.034

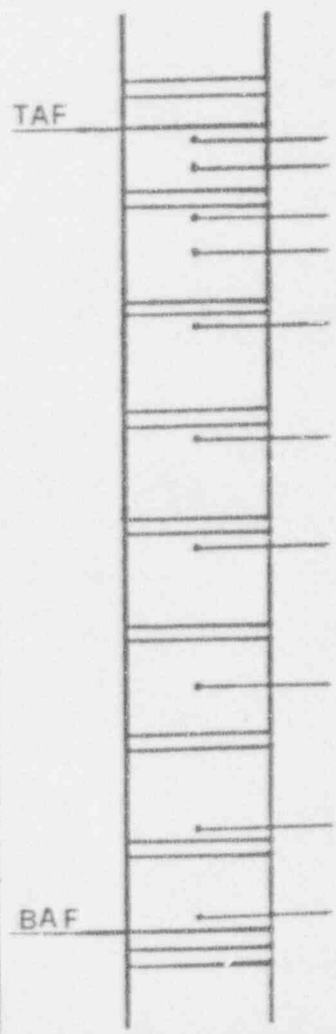
*This flow represents flow from 2 AP600 CVCS makeup pumps.

PRELIMINARY

(*) - rod 3,37,39,44,49,64,93,7,91
(**) - rod 3,37,41,49,64,82
(***) - rod 3,27,37,41,44,64,68,79,82,7,91

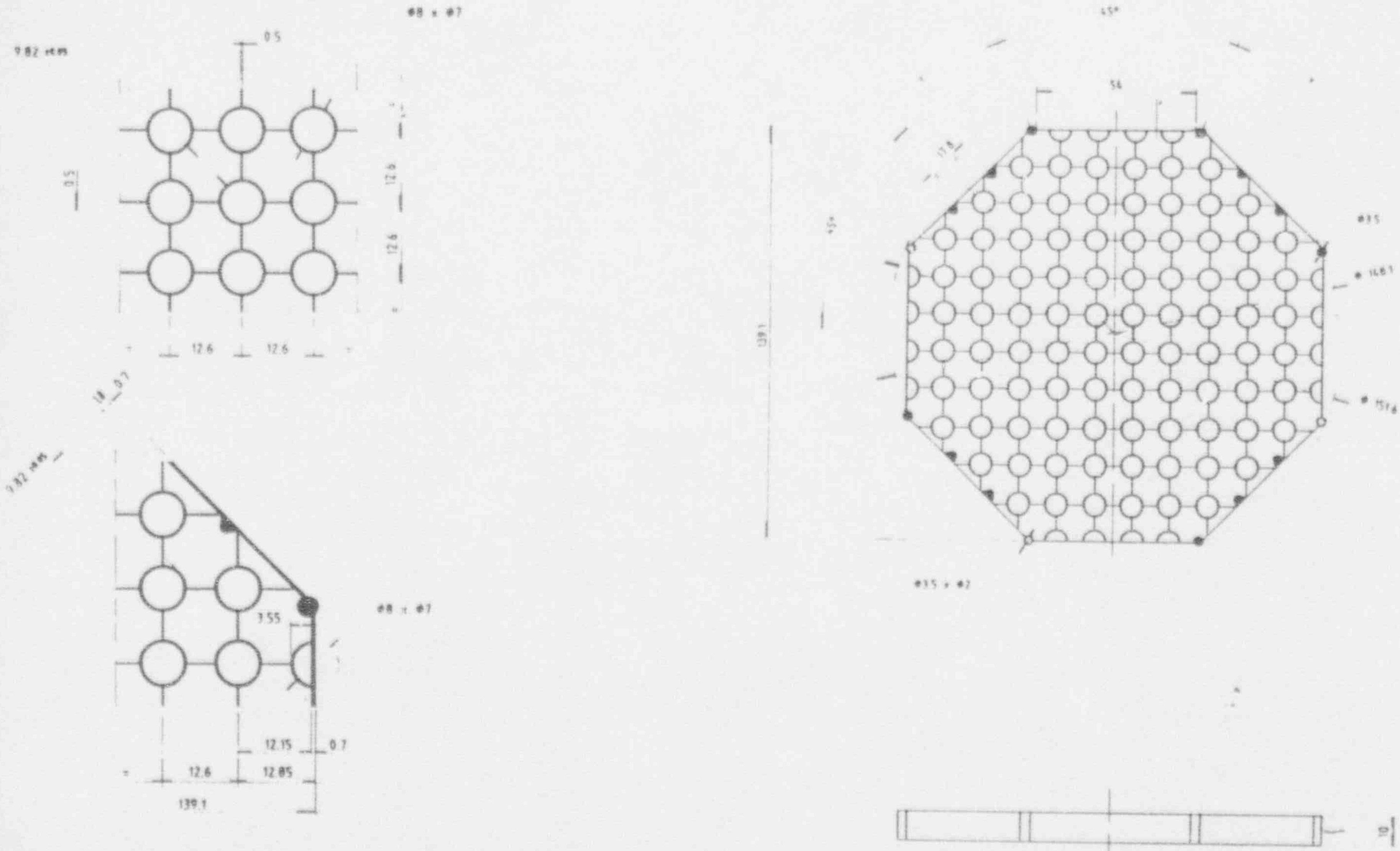






THERMOCOUPLE ELEVATION (□)	
10	3640
9	3474
8	3294
7	3044
6	2794
5	2294
4	1794
3	1074
2	354

(□)-REFERRED TO BAF



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SIET
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HEAB 52

SPES - Canale di Potenza
Nuova griglia distanziatrice fascio

Attachment 2 to Westinghouse Letter ET-NRC-93-3943

The following reports are provided as Enclosures:

1. M. Rigamonti, O. Vescovi, "SPES Pump Characterization", SIET - NT/54, Revision 0, 1987.

2. G. Cattadori, M. Rigamonti, "SPES System Description", SIET - NT/032, Revision 1, 1986.