BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

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SUBJECT: Skylab LOX Tank Vent Lines and Nozzle Temperatures Case 620

DATE: September 21, 1970

FROM: D. P. Woodard

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MEMORANDUM FOR FILE

As pointed out in a recent trip report[1], if the Skylab OWS LOX tank vent lines freeze to the extent that exhaust flow is restricted, heaters may be required to prevent blockage. Attached temperature data show that the lower aft skirt section of the OWS, to which the colder vent nozzle is attached, is likely to reach temperatures below -90°F. At a Beta-angle of -30 degrees, the vent penetration through the LOX tank dome, the vent valve, and the colder vent line are all in close proximity to LOX dome surfaces having temperatures of about 20°F. However, aft skirt temperatures to which these components are exposed radiatively will vary from about -40 to -90°F.

Figures 1 and 2 show two cross-sectional views through the aft end of the OWS. The vent line penetrates the upper aft LOX tank (Figure 1) in sector 8 (Figure 2), branches through the vent valve, and follows two circuitous paths lying below the LOX tank dome. Non-propulsive nozzles are located in sectors 2 and 6 of the lower aft skirt 2.

Temperatures of portions of the OWS aft end that affect the penetration, valve, lines, and nozzles are given in Table 1. These data are keyed to Figures 1 and 2 through the OWS thermal model node numbers given in Column 1. The remaining columns show temperatures at one-tenth orbit intervals beginning at orbital noon. The computations are based on reasonably typical conditions: the baseline solar inertial orbit, a Beta angle of -30 degrees, a foam insulated common bulkhead, and a partially striped OWS meteoroid shield as shown in Figure 3. In addition, sufficient heat has been added to the OWS interior to maintain a 70°F atmosphere temperature immediately above the common bulkhead.

Referring to Table 1, the vent penetration and valve are close to LOX tank node 6208 which has a reasonably constant temperature of about 20°F. Both are exposed to skirt temperatures (node 7208) which vary from about -40 to

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[1] Trip Report - Skylab Venting Propulsion Meeting - Case 620, P. G. Smith, August 21, 1970.

(NASA-CR-113622) SKYLAB LOX TANK VENT LINES AND NOZZLE TEMPERATURES (Bellcomm, Inc.) 8 p

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-70°F. The colder vent line follows closely below nodes 6207 and 6206 which are near 20°F; the respective aft skirt surfaces (nodes 7207 and 7206) again are cold, varying from about -40 to -80°F. In contrast, the opposite vent line and nozzle are much warmer: nodes 6101 and 6102 are around 30°F; and the nozzle node 7202, which is exposed to the sun, varies from approximately 15 to 90°F.

Temperature of the colder nozzle node (7206) is dependent on Beta, being exposed more or less to the earth as Beta varies. Figures 4 and 5 show the temperature variation of node 7206 for Beta angles from 0 to ±73.5 degrees. As shown in both figures, temperatures below -90°F will occur.

D. P. Woodard

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D. P. Woodard

Attachments
Tables
Figures

TABLE 1

OWS AFT END TEMPERATURES, °F

NODE	NOON 0	.1	.2	.3	.4	.5	.6	.7	.8	.9
				ORBIT INTERVALS →						
6101	28.9	28.7	28.7	28.8	29.0	29.2	29.3	29.3	29.2	29.0
6102	30.3	30.2	30.1	30.3	30.5	30.7	30.8	30.8	30.6	30.4
6103	30.3	30.2	30.1	30.2	30.5	30.7	30.8	30.8	30.6	30.4
6104	28.8	28.7	28.6	28.7	28.9	29.2	29.3	29.3	29.1	28.9
6105	27.1	27.0	26.9	27.0	27.2	27.4	27.6	27.6	27.4	27.2
6106	26.9	26.8	26.7	26.8	27.0	27.2	27.3	27.3	27.2	27.0
6107	27.0	26.9	26.9	26.9	27.1	27.3	27.5	27.5	27.3	27.2
6108	27.4	27.3	27.2	27.3	27.5	27.7	27.9	27.8	27.7	27.5
6201	25.0	25.0	25.2	25.5	25.8	25.9	25.9	25.6	25.3	25.1
6202	30.2	30.3	30.6	31.1	31.5	31.5	31.3	30.8	30.4	30.2
6203	30.3	30.4	30.7	31.1	31.5	31.5	31.3	30.9	30.5	30.3
6204	25.0	24.9	25.0	25.2	25.5	25.7	25.7	25.5	25.3	25.1
6205	19.6	19.4	19.5	19.6	19.8	20.0	20.0	20.0	19.9	19.7
6206	19.4	19.3	19.4	19.6	19.8	20.0	20.0	19.9	19.7	19.5
6207	19.5	19.4	19.5	19.8	20.0	20.1	20.2	20.1	19.8	19.6
6208	20.3	20.3	20.4	20.6	20.9	21.0	21.0	20.9	20.7	20.4
6301	28.4	30.8	35.1	40.0	43.1	42.1	38.5	33.4	29.5	27.9
6302	39.3	43.2	48.7	54.7	57.2	53.2	46.9	39.8	36.3	36.8
6303	39.4	42.8	47.6	53.1	55.6	52.0	46.2	39.6	36.4	37.1
6304	28.3	29.8	32.9	37.1	40.4	40.1	37.4	33.2	29.7	28.3
6305	− .2	− .4	.7	2.6	4.3	5.2	5.1	4.1	2.6	1.0
6306	.4	.6	2.1	4.0	5.4	6.0	5.6	4.4	2.8	1.3
6307	.6	.8	2.6	4.8	6.4	7.0	6.5	5.1	3.3	1.6
6308	.4	1.0	3.1	5.5	7.2	7.5	6.8	5.1	3.1	1.4
7101	49.4	51.8	54.2	56.3	56.8	54.9	52.0	48.6	46.9	47.5
7102	110.6	114.2	117.9	121.5	121.9	117.5	111.9	105.7	104.4	107.0
7103	111.3	114.6	117.9	121.3	121.7	117.6	112.3	106.5	105.5	108.0
7104	49.7	50.8	52.2	53.7	54.4	53.1	51.1	48.7	47.8	48.5
7105	−20.1	−19.9	−19.6	−19.4	−19.4	−19.4	−19.6	−19.7	−19.9	−20.1
7106	−18.5	−17.2	−15.9	−15.9	−15.0	−15.5	−16.3	−17.2	−18.2	−18.8
7107	−11.3	− 9.3	− 7.2	− 6.2	− 6.2	− 6.9	− 8.1	− 9.5	−11.0	−11.9
7108	− 7.8	− 6.1	− 4.3	− 3.3	− 3.2	− 3.8	− 4.9	− 6.1	− 7.4	− 8.2
7201	1.1	10.5	17.6	21.1	8.7	− 5.5	−18.1	−26.3	−18.3	− 9.0
7202	63.0	71.7	80.6	88.7	64.6	42.6	25.2	15.2	37.3	52.5
7203	62.2	69.0	76.9	86.0	64.7	46.5	32.0	22.3	42.4	54.4
7204	− 3.4	− 1.0	4.3	11.6	6.4	6.8	− 5.3	−11.5	− 6.4	− 4.4
7205	−75.9	−74.6	−72.3	−70.5	−69.3	−69.2	−70.0	−72.1	−74.5	−75.8
7206	−73.4	−64.8	−60.8	−62.4	−67.3	−73.6	−79.8	−84.4	−85.9	−82.0
7207	−61.6	−48.1	−43.8	−48.1	−56.6	−65.8	−74.4	−81.0	−82.9	−76.2
7208	−55.9	−44.4	−39.6	−42.0	−48.5	−56.8	−65.0	−71.4	−73.3	−67.9
7301	−67.7	−11.3	21.1	8.1	−10.3	−36.3	−64.8	−88.1	−99.5	−98.2
7302	−46.9	7.5	36.5	23.1	4.7	−22.7	−52.0	−75.7	−84.7	−79.5
7303	−46.4	7.2	35.8	22.4	4.3	−22.6	−51.2	−74.4	−83.3	−78.3
7304	−67.0	−12.7	18.5	5.5	−12.1	−36.8	−63.9	−86.0	−96.8	−95.9
7305	−92.1	−35.6	− .2	−12.4	−30.7	−55.3	−82.6	−104.9	−117.6	−119.6
7306	−92.0	−33.6	2.7	− 9.6	−28.6	−54.1	−82.5	−105.6	−118.9	−120.7
7307	−94.3	−34.5	3.0	− 8.9	−28.1	−54.1	−83.1	−107.0	−121.1	−123.4
7308	−89.8	−31.1	5.3	− 6.9	−25.9	−51.5	−80.1	−103.4	−117.0	−118.8
7401	66.8	78.5	84.0	84.6	58.4	35.1	18.0	10.2	31.4	50.3
7402	170.3	181.5	189.7	195.6	142.1	101.5	74.6	66.3	118.9	151.6
7403	168.4	178.1	185.8	193.1	142.1	104.5	79.9	71.8	122.7	152.2
7404	58.4	63.3	68.8	74.6	55.4	39.3	27.6	21.5	40.2	51.8
7405	−55.8	−53.9	−53.4	−54.8	−55.8	−56.5	−57.3	−58.4	−59.3	−58.1
7406	−45.7	−36.2	−35.4	−41.2	−48.1	−54.8	−60.3	−63.9	−64.3	−57.8
7407	−30.2	−15.3	−15.1	−24.4	−35.1	−44.7	−52.6	−58.0	−58.8	−49.3
7408	−28.2	−15.6	−14.5	−21.8	−30.7	−39.4	−46.6	−51.6	−52.3	−44.0
8101	26.3	38.4	49.4	54.3	42.3	28.9	16.2	7.0	12.7	18.1
8102	81.8	94.5	107.0	114.7	88.3	64.1	44.4	33.2	55.2	70.0
8103	81.0	91.9	104.0	112.8	88.0	65.3	46.2	35.1	56.6	70.7
8104	21.3	28.5	38.5	46.3	38.6	29.0	18.6	10.0	14.9	17.9
8105	−37.6	−31.7	−23.9	−19.8	−18.0	−19.2	−23.1	−28.6	−34.1	−37.9
8106	−25.4	−15.3	− 7.3	− 6.5	− 8.8	−13.4	−19.1	−24.9	−29.4	−30.6
8107	−40.3	−26.5	−15.8	−14.6	−17.9	−24.1	−31.6	−39.2	−45.6	−47.3
8108	−29.2	−17.2	− 7.8	− 6.9	− 9.8	−15.3	−22.0	−28.6	−34.1	−35.4
531	140.3	140.1	129.8	117.5	1.5	−49.4	−74.0	−55.3	82.1	126.5
532	233.7	234.9	238.1	239.9	37.2	−11.5	−30.5	27.6	232.8	236.0
533	228.3	228.9	234.4	240.3	43.9	5.8	− 8.6	44.7	232.2	230.8
534	106.1	107.9	115.2	122.0	22.7	− 8.2	−22.0	− 9.3	94.3	108.3
535	−68.1	−59.2	−60.9	−71.6	−78.3	−83.1	−87.1	−91.8	−93.8	−82.7
536	−13.0	10.6	−14.2	−55.7	−89.0	−114.4	−131.0	−136.2	−124.0	−75.9
537	33.9	57.0	12.8	−44.7	−88.8	−120.1	−140.8	−148.8	−131.5	−60.4
538	25.9	47.9	14.2	−34.2	−72.4	−102.2	−122.0	−129.0	−112.9	−51.0

SOLAR INERTIAL ORBIT, $\beta = -30°$, $Q_{INTERNAL} = 0$, $T_{GAS} = 70°F$, INSULATED - T225 STRIPING

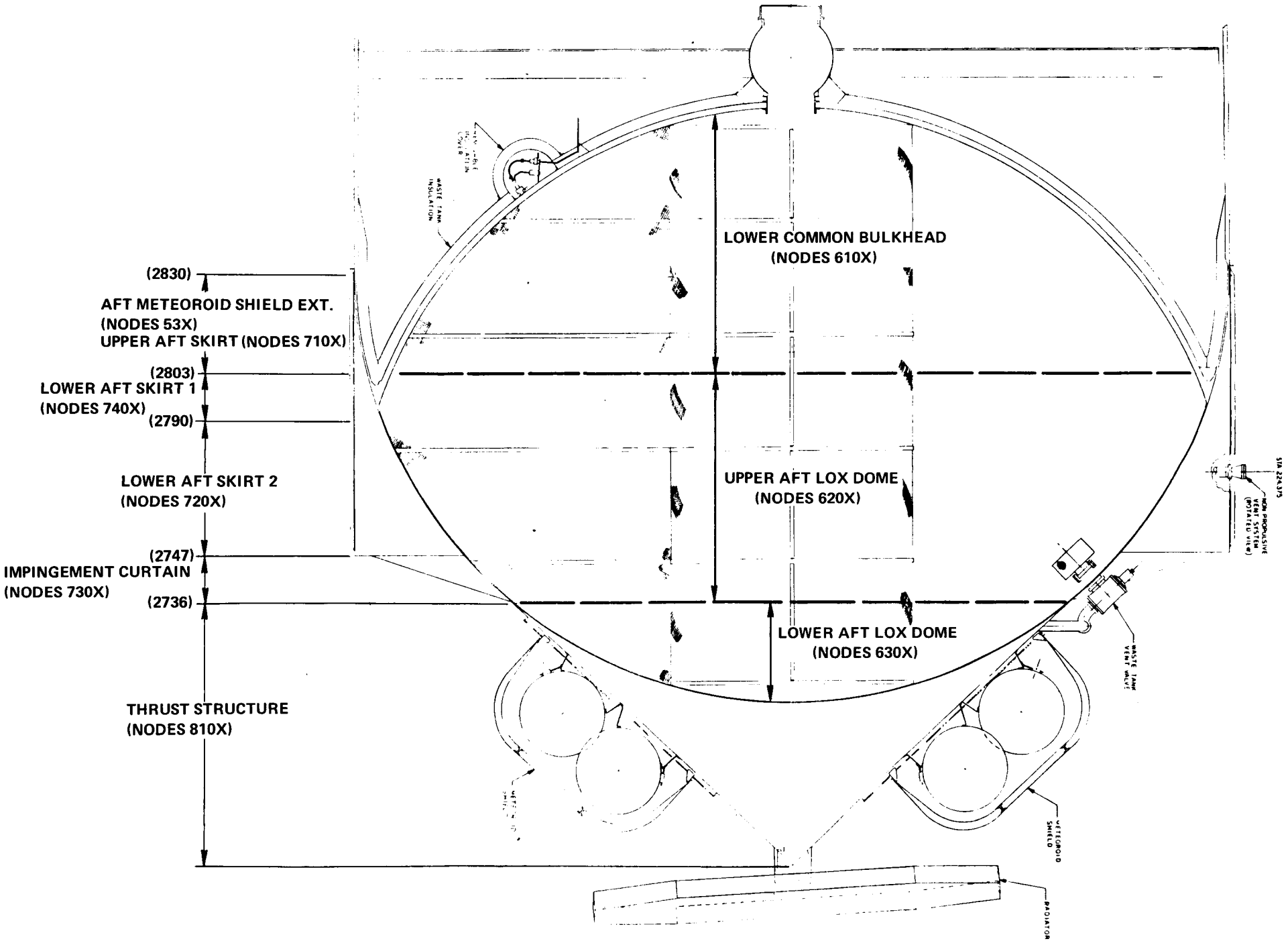

FIGURE 1 - OWS LONGITUDINAL NODE LOCATIONS

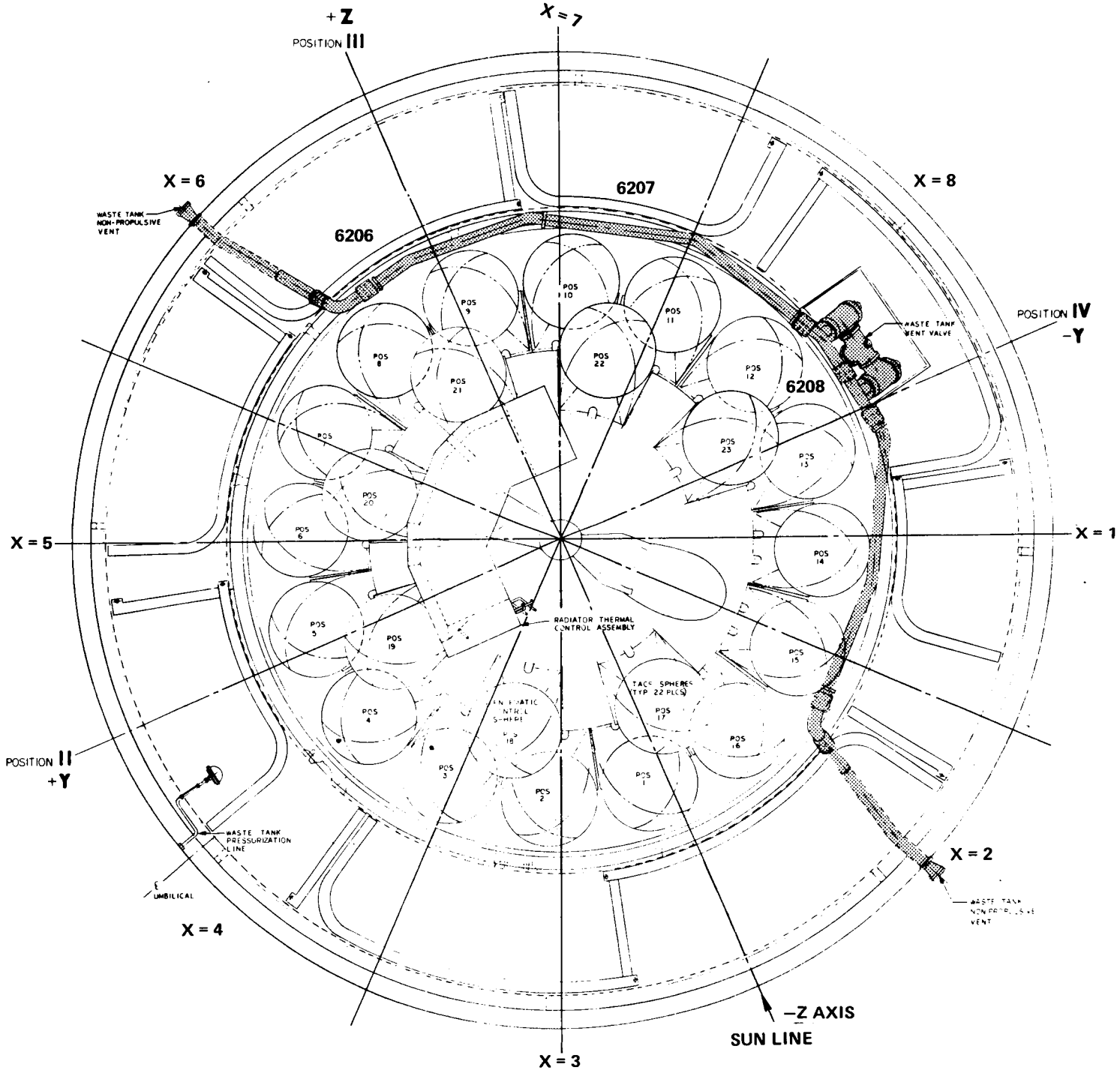

FIGURE 2 - QWS CIRCUMFERENTIAL NODE LOCATIONS

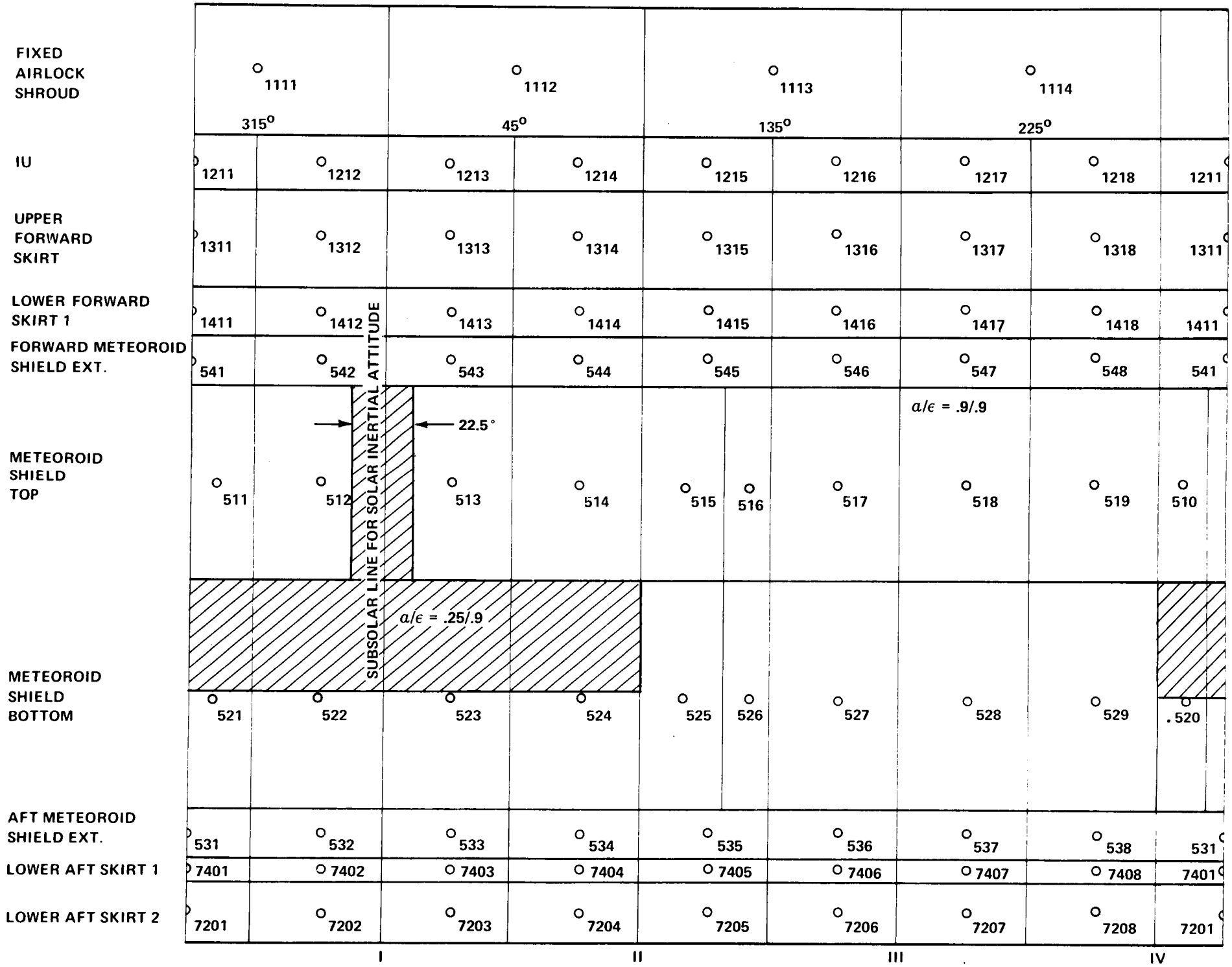

FIGURE 3 - CIRCUMFERENTIAL LOCATION OF EXTERIOR THERMAL NODES – T225 STRIPING

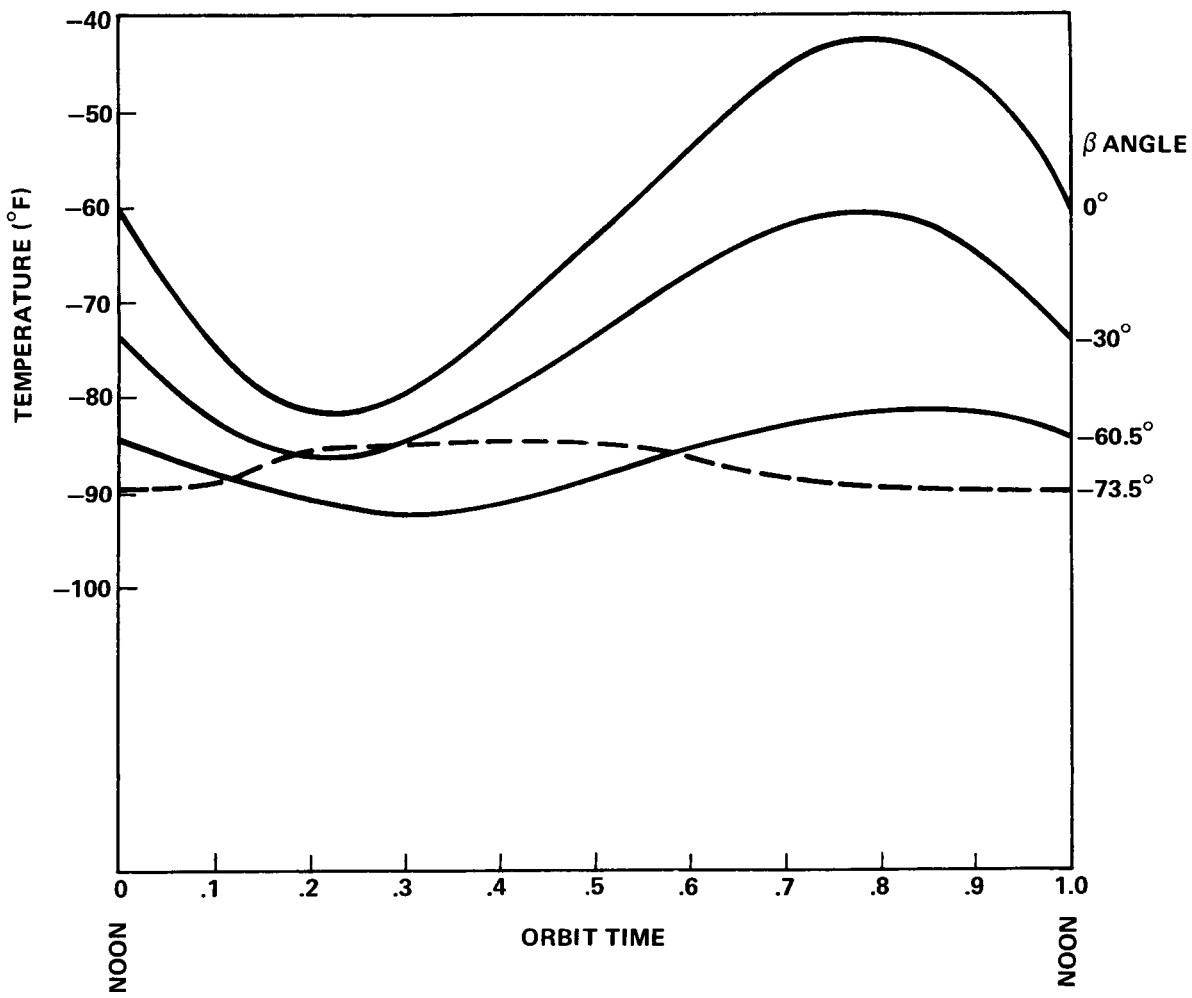

FIGURE 4 - TEMPERATURE OF EARTH SIDE NOZZLE NODE (7206) FOR NEGATIVE BETA ANGLE

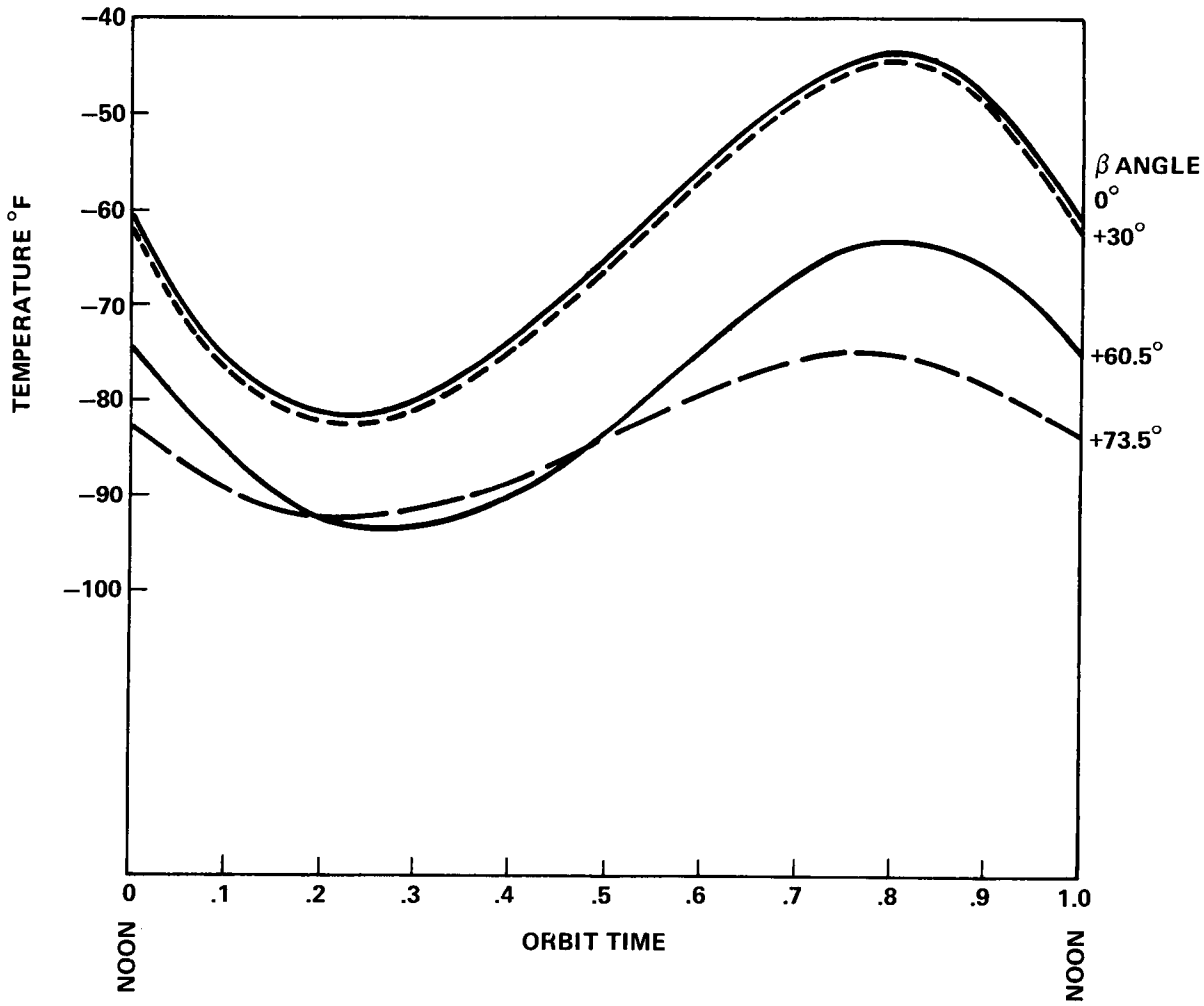

FIGURE 5 - TEMPERATURE OF EARTH SIDE NOZZLE NODE (7206) FOR POSITIVE BETA ANGLE

BELLCOMM, INC.

Subject: Skylab LOX Tank Vent Lines and Nozzle Temperatures Case 620

From: D. P. Woodard

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