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HANDLING OF SODIUM FOR THE FFTF

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INTRODUCTION

Much of the experience with large sodium systems at HEDL came from the High Temperature Sodium Facility (HTSF). This facility contains 1.7×10^5 Kg (375,000 lbs) of sodium and this material was ordered, received and placed in the large tankage as part of the HTSF project in 1973. This provided an excellent learning process for the later activities necessary to complete the FFTF sodium procurement and handling work.

SODIUM PURITY

Most of the work surrounding the use of sodium relates to its purity and the maintenance of that purity after arrival and in the handling operations. All the material used in the Hanford Engineering Development Laboratory (HEDL) Program is of reactor grade purity. Table Nos. 1 and 2 show some of the acceptable impurity levels and represent both the vendor and HEDL analyses. In discussion of purity several points should be made. The first, the major problem

in the use of commercial grade sodium lies in the amount of calcium present. This impurity comes from both the raw material salt used to obtain the sodium and the addition of calcium compounds in the electrolytic process used to decrease the melting point of the salt mixture. The second type of impurity is boron, a neutron absorber. It is best kept at very low levels. The major cost in the purification of commercial grade to reactor grade is the reduction of calcium from 200-300 ppm to less than 10 ppm. The justification for low Ca comes from past experience in operating mechanisms in commercial grade sodium (containing 200-300 ppm calcium) and incidents of fouling.

Both the HTSF and FFTF sodium have been purchased successfully with the low calcium and low boron levels. In addition, special precautions were taken to prepare and clean tank cars and systems into which high purity sodium was placed. This means clean and free from debris and the use of cover gas free of oxygen and moisture to prevent further contamination.

HTSF HANDLING EXPERIENCE

HTSF experience consisted of negotiations with and purchase of sodium from E. I. duPont Corporation. It required six months lead time for the 1.7×10^5 Kg (375,000 lb) order. It was delivered in five tank cars in solid form with an atmosphere of nitrogen gas over the top. The cover gas atmosphere was introduced at the production plant and was 34.5 kPa gage (5 psig). The tanks arrived on site with an overpressure gage of about 28 kPa (2 psig). A gage pressure of about 34.5 kPa (5 psig) was re-established and then maintained during the time it was in the tank car. The tank cars were stored on the siding at HEDL for six months before the system was ready for sodium fill. Tank car heatup took place in a specially constructed melt station. The melt station used hot heat transfer oil to heat the tank car. After melting, the molten

sodium was subsequently transferred from the tank car by a pressure differential of 82.7 kPa (12 psi) of nitrogen. (Figure 1) The car contents were heated to 149°C (300°F) for transfer. The system piping and tank were maintained at 177°C (350°F) by the trace heating of insulated piping. It required about 24 hours for the tank cars to raise from ambient temperature to 177°C (350°F). It required from 10 to 12 hours for the content of the tank car 3.4×10^4 Kg (about 75,000 lbs) to be removed and placed in the tank for storage. Details of the system can be found in HEDL TME-74-14.

The sodium was filtered using 20 micron sintered stainless steel filters arranged in a tandem by-pass. This arrangement allowed one filter to be isolated for cleaning without interrupting flow. Filters were scheduled to be cleaned if the pressure drop became excessive. In addition to the filter operation, the sodium material underwent sampling. Each tank car had a single sampling run which diverted a part of the flow to fill two overflowing cups. These cup samples were then analyzed and averaged to arrive at a composite purity figure as seen in Table 2. Details of the sampler can be seen in HEDL TME-74-14.

No difficulties were encountered in any of the handling operations. Personnel protective equipment was required and fire protection people were on standby during the operation in the case of a sodium spill.

The sodium tank cars were unloaded to leave a heel of about 5% of the total volume. This is accomplished by lowering the sodium level down to within two inches of the eductor pipe end. The practice of leaving the heel allows settling of particulate matter in the sodium or that introduced from the railway car or the storage process. This heel is then removed by the vendor and discarded during the tank car cleaning process.

PURCHASE AND RECEIVING OF THE FFTF SODIUM

The sodium for the FFTF was also supplied by E. I. duPont. Owing to the large order, 7.71×10^5 Kg (1.7×10^6 lbs), the vendor built special handling facilities. These were a new process holding vessel and an unloading station dedicated to reactor grade material. The total order required almost two years lead time in order to bring the new facilities on line and to produce the required sodium. The actual time of sodium production was about seven months. It started in February 1976 and was completed by August 1977. The FFTF sodium analysis is shown in Table 3. It required four more months to transport the sodium material to the site in tank car lots. (Figure 1) The entire order filled twenty-two tank cars. These were stored in a controlled area and monitored to insure that an inert cover gas was present.

PLANS FOR HANDLING THE FFTF SODIUM

Based on the successful experience of the HTSF, procedures have been written to heat the tank cars, filter the sodium and place it in the reactor systems. The sodium in the tank cars will be heated to $149^\circ\text{C} \pm 9^\circ$ ($300^\circ\text{F} \pm 15^\circ\text{F}$). (Figures 2 and 3) All connecting piping and the reactor systems into which the sodium will be going are heated to $177^\circ\text{C} \pm 9^\circ$ ($350^\circ\text{F} \pm 15^\circ\text{F}$) with in-place trace heaters. Heatup rates are 14°C (25°F)/hr in a dry condition or 6°C (10°F)/hr in the sodium wetted condition. Tank flow is to be cut off when the level in the tank is at 0.13 m (2 inches) from the bottom of the tank car eductor pipe. The sodium is moved from the tank by imposition of 82.7 kPa gage $\pm 14 \text{ kPa}$ ($12 \text{ psig} \pm 2 \text{ psig}$) with a maximum of 96.5 kPa (14 psig) on that system. The sodium will move through the sintered metal filters arranged in parallel to allow switch for filter cleaning or replacement. All areas where a possible sodium spill could take place have been equipped with catch pans to restrict

the movement and reduce the surface of the sodium. Protective equipment is worn by all operators and fire equipment is on standby. Protective equipment consists of high topped leather shoes, flame retardant coveralls, hard hat with face shield, and long gauntlet rubber gloves.

Actual fill of the reactor systems is divided into loop sections of either the primary and secondary systems. (Figure 4) Reactor systems will be filled from the main tankage by pressurization of the tanks. It is anticipated that less than 140 kPa gage (20 psig) will be necessary, but some special areas will utilize as much as 241 kPa gage (35 psig). Freeze vents will, in some places, require use of a vacuum imposed on the outlet vent side in order to insure that frozen sodium is in place. Special sodium detectors working on the eddy current principle are used to determine the presence of and the position of the sodium level in the freeze vents.

SPECIAL PROTECTIVE SUIT

In conjunction with the use of large quantities of sodium, HEDL has developed a sodium protective suit. (Figure 5) This suit is designed for emergency conditions where it would be necessary to enter an area with sodium spray. It is designed for the purpose of protecting an individual for a period of two minutes where he has burning sodium 1093°C (2000°F) sprayed on him. The suit is constructed of several layers to provide the protection required. The outer material layers protect a foil layer from handling. The foil layer is inserted to prevent penetration of sodium through the fabric. It is backed by a layer of insulation material for protection from the heat. The suit has been extensively tested in liquid sodium to demonstrate its effectiveness and ability to stand up to these conditions. This suit will be used by fire personnel because it requires use of a self-contained breathing device and the fire people are the only personnel on the site that routinely use these devices.

SUMMARY

Based on the HTSF experience and the extensive design efforts made by the Westinghouse people assigned to FFTF, procedures are in place for the unloading of the tank cars and for the fill of the reactor. Special precautions have been taken to provide safe handling and to accommodate contingencies in operation. These contingencies include special protective suits allowing personnel to enter and correct conditions arising from fill operations in the course of moving 7.71×10^5 kg (1.7×10^6 lbs) of sodium from the tank cars into the reactor vessel and its loop system.

TABLE 1
VENDOR BATCH ANALYSIS OF HTSF SODIUM

<u>Batch No.</u>	<u>72-4</u>	<u>72-5</u>	<u>72-6</u>	<u>72-7</u>	<u>72-8</u>	<u>73-1</u>	<u>73-2</u>	<u>73-3</u>	<u>Average</u>
Total sodium purity (%)	99.95	99.98	99.90	99.96	99.93	99.94	99.92	99.91	99.94
Calcium (ppm)	0.4	8.5	10,<2	3.3	3.4	<1	8.6	4.0,0.14	≤4.4
Carbon (ppm)	4.5	24	6.2	1.6	5.5	1.4	5.4	2.7	6.4
Chloride (ppm)	1.7	0.7	0.7	≤20	30.6	0.3	6.5	<0.5	≤7.6
Potassium (ppm)	370	350	410	406	370	326	350	330	364
Boron (ppm)	0.025			≤0.3	≤0.2	≤ .01		0.30	≤0.17
Lithium (ppm)	<0.1			≤0.3	0.4	≤0.2		<0.01	≤0.20

TABLE 2
HEDL ANALYSIS OF HTSF SODIUM

IMPURITY	#1	#2	#3	#4	#5	AVERAGE
Ag	.02	.35	.05	.25	.17	0.17
Al	<.02	.04	<.02	<.02	<.01	<0.022
Au	<.004	<.004	<.004	.015	<.002	<0.006
B			All less than 0.5			<0.5
Bi			All less than 0.01			<0.01
Ca	.03	.04	.03	.06	.01	0.03
Cd			All less than 0.01			<0.01
Co	<.004	<.004	<.004	.005	<.002	<0.004
Cr	.02	.13	.06	.17	.12	0.10
Cs			All less than 0.01			<0.01
Cu	.05	.11	.13	1.15	.04	0.3
Fe	.15	.53	.41	.95	.43	0.5
K	350.	340.	390.	385.	370.	370.
Li			All less than 0.001			<0.001
Mg	<.003	.013	.04	.011	.007	<0.015
Mn	.002	.008	.004	.015	.025	0.011
Mo	<.04	<.04	<.04	<.03	<.02	<0.034
Ni	.11	.06	.11	.12	.05	0.09
Pb	<.005	.05	<.007	.03	.007	<0.020
Rb	.02	.03	.03	.03	.02	0.026
Sc			All less than 0.03			<0.03
Sr			All less than 0.003			<0.003
U			Composite less than 0.001			<0.001
V			All less than 0.02			<0.02
Zn	<.01	<.01	<.01	.03	<.01	<0.014

TABLE 3
FFTF SODIUM ANALYSIS BY VENDOR

Tank Car Number	(Assay % Na+K)	Element Concentrations in PPM								Lot #
		<u>Ca</u>	<u>Cl</u>	<u>K</u>	<u>C</u>	<u>B</u>	<u>Li</u>	<u>S</u>	<u>U</u>	
Closed Loop Drums	99.99	< 1.0	< 3	350	3.1	3.0	0.1	0.6	.001	--
7505	99.98	1.0	3	210	15.1	2.4	0.3	.06	.001	76-3
7984	99.98	1.0	3	250	3.9	1.8	< 0.1	.02	.003	76-4
7980	99.98	1.0	3	300	1.6	2.5	< 0.1	0.4	.006	76-5
7983	99.98	1.0	3	225	2.2	< 0.1	< 0.1	.06	.007	76-6
7985	99.99	1.0	3	265	2.6	3.2	< 1.0	.22	.003	76-7
7987	99.97	1.0	3	270	7.9	3.3	< 1.0	.06	.003	76-8
7806	99.98	1.0	3	260	0.8	0.7	< 1.0	0.1	.008	76-13
7904	99.98	1.0	3	260	0.7	0.8	< 1.0	0.1	.010	76-14
7210	99.96	1.0	3	280	0.5	0.47	< 1.0	0.1	.010	76-12
7807	99.96	1.0	3	275	1.2	0.67	< 1.0	0.05	.008	76-11
8504	99.98	1.0	3	240	1.5	0.46	< 1.0	0.1	.03	76-15
7901	99.96	1.0	3	280	1.1	0.1	< 1.0	0.1	.008	76-16
8904	99.98	1.0	3	270	2.8	0.1	< 1.0	0.1	.006	76-17
7209	99.97	1.0	3	270	2.5	0.08	< 1.0	0.1	.008	76-18
7986	99.97	1.0	3	285	4.9	0.20	< 1.0	3.0	.007	76-19
8500	99.98	1.0	3	280	1.0	0.2	1.0	0.1	.008	76-20
8506	99.97	1.0	3	300	1.9	0.2	1.0	0.2	.005	76-21
7811	99.97	1.0	3	280	3.8	0.2	1.0	1.0	.007	76-22
8503	99.96	1.0	3	300	1.7	0.2	1.0	1.0	.007	76-23
7208	99.96	1.0	3	235	1.6	2.0	1.0	.17	.004	76-9
7805	99.96	1.0	3	270	1.9	0.2	1.0	.13	.003	76-10
$\bar{X}$	99.97	< 1.0	< 3	270.7	2.87	1.39	< 1.0	3.61	.006	
σ	.0099	---	-	29.37	3.21	1.85	---	5.99	.003	
Spec (Max)		10.				10.				

FIRE

BATTLE 170701 7642001

Labelation:
Vacuum Connection
Pumping Station

Vent ← V-T41

VACUUM PUMPING UNIT (P-137)

VENT LOCALLY OR TO CAPS

delete

**SODIUM TANK CAR
STATION SETUP**

SODIUM TANK CAR CONE CONNECTIONS

TAK 12-12-77

FIGURE 7

FTT 1000
AND

CALCULATED CAPACITIES OF SYSTEMS
GALLONS OF SODIUM AT 700°F.

REACTOR VESSEL	69,100
HTS PRIMARY LOOPS	42,700
HTS SECONDARY LOOPS	17,700

FIGURE 5.

SODIUM PROTECTIVE SUIT

BATTLE # 7611292 15w