7. Vapour Trap Development and Operational Experience by W. JANSING, G. KIRCHNER, J. MENCK, Federal Republic of Germany

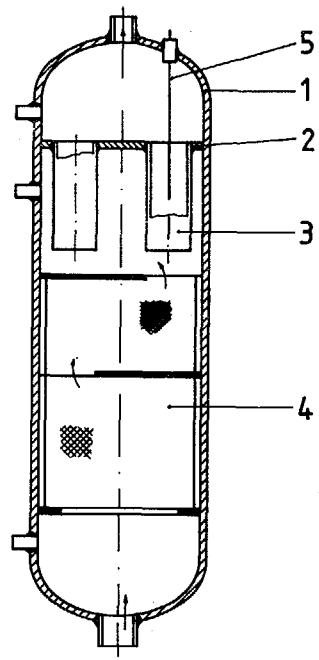
Sodium aerosols have the unpleasant characteristic that they deposit at places with a low temperature level. This effect can be utilized, however, when sodium aerosols are to be trapped at places which are determined beforehand. Thus vapour traps were developed which can filter sodium vapour from the cover gas. By this means the necessity was eliminated to heat all gas lines and gas systems with trace heaters just as all sodium lines are heated. It was of special interest for the INTERATOM developmental program to develop vapour traps which have not to be changed or cleaned after a certain limited operating period. The vapour traps were supposed to enable maintenance free operation, i.e. they were to operate "self-cleaning".

14 vapour traps were employed at the KNK-reactor which have been in operation for more than 30.000 working hours each. 8 of these vapour traps are designed for 0.25 std m^3/hr argon flow and 6 units are designed for 1.0 std m^3/hr argon flow. No difficulties arose with the operation of these vapour traps. No additional filters were fitted in series with these vapour traps. No sodium deposits could be traced behind the vapour traps at no place of the system up to now.

The KNK vapour traps were modified and designed for higher flow capacity for use at the SNR-300. The KNK vapour traps were designed for a nominal flow rate of 1 std m^3/hr, the SNR-300 units will permit flow rates of 20 std m^3/hr.

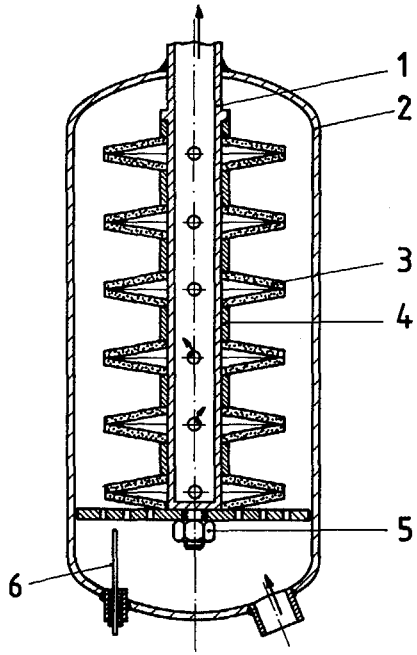
At the time being there are two different types of vapour traps in use in the INTERATOM test facilities. These vapour traps mainly differ in structure and allowable flow capacity. The allowable specific flow capacity for both types generally is 2.5 std m^3/m^2.hr on the average. The so-called swirl chamber trap which was formerly employed was not further developed as the possible flow capacity was limited and the efficiency of precipitation was only 99.8 %.

Vapour trap for a flow capacity of 3 std m^3/hr



These vapour traps consist of a pressure vessel (1) in the upper side of which a baffle plate (2) is welded. The baffle plate serves to support the candle filters (3). A maximum of 7 filters can be provided. The lower part of the vapour trap houses a cage which is filled with steel wire cloth (4) and which already brings a good precipitation effect. The gas enters the vapour trap at the bottom side and leaves it at its top. The precipitated sodium flows back through the gas line itself in counterflow to the gas. Survey of the gas temperature and control of the trace heating are taken care of by thermocouples (5) which extend into the candle filters on the clean gas side.

Vapour trap for higher flow capacity



In this kind of vapour trap a central suspension tube (1) is welded in the pressure vessel (2). The suspension tube alternately carries filter discs (3) and metallic ring gaskets (4). The filter discs and metallic ring gaskets are tightened together by the use of a lock screw (5). Thus the cover gas cannot pass between filter and gaskets but can penetrate through the filter discs. The suspension tube is outfitted with holes in the reach of the filter discs. The designed flow capacity settles the required number of the filter discs. The trace heating is controlled by the thermocouple (6) in the gas entry chamber. The precipitated sodium flows back from here in counterflow to the contaminated argon via the gas suction line.

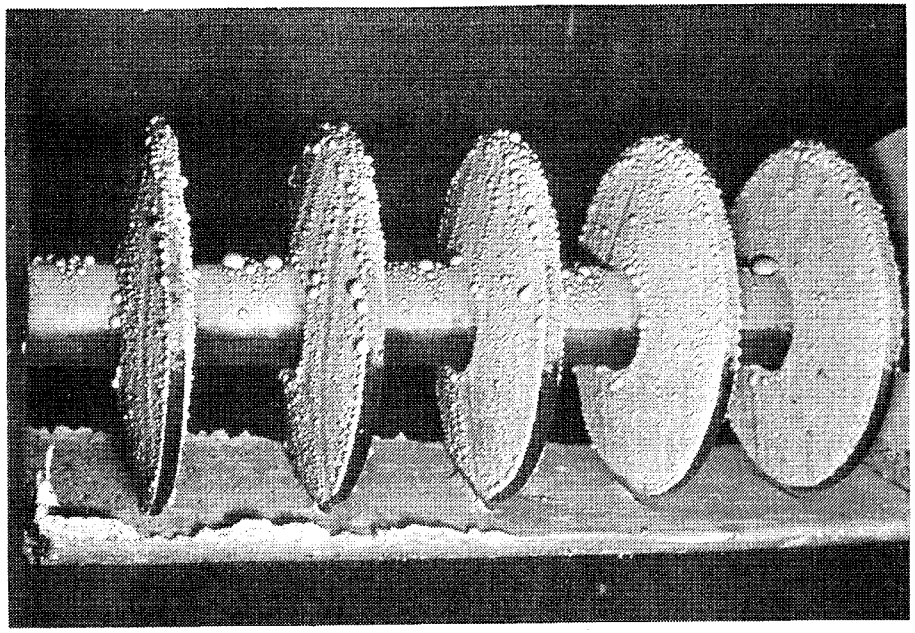
Vapour traps of this design were already built for flow capacities of 25 std m^3/hr and 60 filter discs were required for this duty.

The cleaned gas is conducted through the central suspension tube back into the circuit. The aerosols which are precipitated at the filter discs form small sodium drops which enlarge until they are big enough to drain by gravity force. The smallest sodium drops which are located below the rinsing sodium drops are swept away by this process. Thus sodium-free paths are created at which the filter surface is free and well permeable again.
The sodium vapour traps do not show any pressure loss at the first starting. It is observed not before a certain operation period that the pressure loss rises relatively fast. The operation of the sodium vapour traps can be devided in three phases in relation to the pressure loss behaviour.

First phase: no pressure loss. Sodium aerosols deposit at the filter surface, obstruct an amount of pores and reduce the free section of the filters until a pressure loss is present at all.

The second phase begins at this condition. The pressure loss rises relatively fast. The quick rise of the pressure loss results from the reduction of the free filter section to approximately 1 - 1.5 % of the originally offered filter surface.

Third phase: This phase is characterized by unsteady behaviour of the actual pressure loss with respect to the average pressure loss. This means that the free filter surface is not further reduced. The precipitated sodium aerosols form drops at the filter surface which enlarge continuously and drain from the filter surface by gravity force because of their viscosity.



Sodium-free paths are formed this way which give free a certain amount of pores again and allow the pressure loss to fall for some amount. The necessary supposition for a trouble-free function of the vapour trap is the forming process of sodium drops.

Several factors clearly take influence on the draining process. These are the temperature at the filter discs, the temperature of the incoming gas, the purity of the sodium aerosols, the purity of the cover gas, the roughness of the filter disc's surface, and the size of the pores. The temperature of the incoming gas can be controlled by a cooler/heater-unit which is installed before the vapour trap. The sodium which drains from the filter discs flows back into the sodium system via the gas line itself. Operation of the vapour traps is influenced by impurities which are carried along.

The tolerable levels are:

H_2	$\leqq$	50 vpm
O_2	$\leqq$	10 vpm
N_2	$\leqq$	1000 vpm
humidity	$\leqq$	10 vpm

An undisturbed operation can be guaranteed under these conditions. The filter disc type vapour trap was operated in the test facilities for 3000 hrs with a total flow capacity of 40,000 std m^3 at 560°C sodium temperature. The aerosol concentration was 21 - 23 gr Na/std m^3 in the cover gas during the tests. This value was determined by collecting the sodium which flows back in a special drain tank. Including all components as heater, cooler, piping and vapour trap, the overall efficiency of the circuit came to 99.999 % during this operating period.

The vapour trap was tested under aperiodically fluctuating operating conditions between 0 and 100 % flow rate, too. It was not established during these tests that the readiness for operation subsided at all. Another vapour trap of this model was employed with good result at the gap clearance scavenging circuit of the RSB test facility. This vapour trap which was designed for a flow capacity of 3 std m^3/hr was operated for 4300 hrs at 400 - 600°C sodium temperature. The aerosol concentration of the cover gas was 24 gr/std m^3 at this place, too. The efficiency of the precipitation was 99.9939 % in this case. The SNR-300 will be equipped with a total of 37 vapour traps with 20 std m^3/hr flow capacity each. These vapour traps can be utilized under vacuum condition with good success, too. Very good experience was especially made in connexion with vacuum destillation. Test vessels are heated up to 560°C for vacuum destillation. The pressure in the test vessel is then pumped down below the vaporization point of sodium via a vapour trap by the use of a vacuum pump. The vapour trap works well and reliably under these operating conditions, too.