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# Körting
# Information

# Trouble Sources
# in Vacuum Plants
## Locating and Remedy

A 13-1977 (ME12-4)

## 1.0 Preface

Steam jet ejectors rarely fail or have a reduced performance if they are working under operating conditions according to design. In our "Instructions A 12 and 12-3 for assembly and operation of multi-stage steam jet ejectors" advice is given concerning troubles and defects occurring if the required performance of the unit is not achieved due to an assembly defect or similar.

In principle, these explanations are also valid for breakdowns which occur gradually or suddenly after a period of operation.

Wear or dirt can be cause. In order to minimize the time to locate the problem, according to the symptoms, the following procedure should be followed.

After an external inspection and a temperature difference check, the following performance checks are made.
Dismantling and internal inspection is only rarely necessary.

Repeated procedure is described under pos. 2.0 "Fundamental Terms" and the possible defects with their detection is shown under pos. 3 to 6.

## 2.0 Fundamental Terms

### 2.1 Hydraulic Test (Leak Test)

Leaks can occur in the ejectors or in the process plant.
Both are checked together or separately by a hydraulic test.
With barometric units also the tail pipes -especially the older ones- should be included in any check.
Small diameters can be sealed by wooden plug, lager ones by a clamping flange.

When filling the unit elements must be blead at the highest point to ensure complete filling. Break a flange connection at the top of the unit.
The water pressure should be 0.5 to 1 bar gauge.

**Never pressurize with steam.**

If the process cannot accept water, then compressed air can be substituted using soap solution to indicate leaks.

## 2.2 Performance Test

A performance test of the ejectors should always be separated from the process plant. If a vacuum shut-off valve is not available, the first stage ejector can be turned in the longitudinal axis according to the number of holes in the flange. The suction connection is fitted with a blind flange with a threaded hole of 1/2" in which the test nozzle is screwed, either supplied by us or in case of need locally produced (see also "Information A 12 and 12-3", page 7, pos. 6.8).

A further connection to the blind flange must be provided fora vacuum gauge. To measure the interpressure in the individual stage of multi-stage ejectors use the socket joints on the inter condenser. The measurements are compared with those in the operating Instructions.
They should also be noted for later comparison.

## 2.3 Zero Load Test (Shut Off)

For a quick and simple intermediate test check of the shut-off behavior often is sufficient. When the process plant is shut off and no air is admitted, i.e. at zero load, a steam jet ejector should attain about half suction pressure, for example, 5 mbar instead of 10 mbar. If this can be attained, no major defect can exist.

## 2.4 Measuring Instruments

Suitable measuring instruments and measuring methods are fully described in Körting Information A3 and M 12-6.

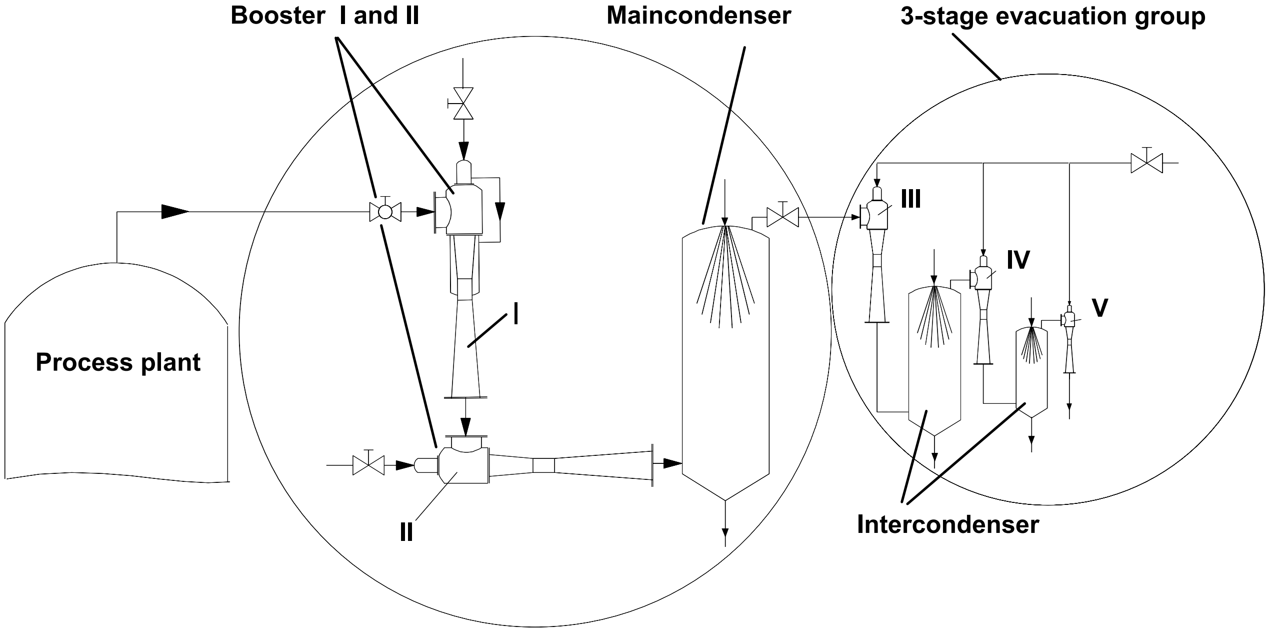
## 3.0 Provisions and recommended sequence for fault finding

When after a period of operation a multi-stage steam jet ejector gradually or suddenly decreases in performance, the reasons can be external influences or internal variations.
If the defect cannot be recognized at once, the tests are started from the last stage delivering to atmosphere.
Only when this stage delivers the provided pre-vacuum can the preceeding stage operate with the design back pressure.

The stages are numbered in the direction of atmospheric pressure.

Thus the first stage is connected to the process plant to be evacuated
to a condenser.

In order to further rationalize the fault finding procedure the two construction types should be differentiated (see sketch).




On the one hand, single and multi-stage steam jet ejectors, evacuating condenser units and for maintaining the vacuum appropriate to the cooling water discharge temperature (evacuation group).

On the other hand, the multi-stage steam jet ejectors producing a vacuum higher than the condenser vacuum, and for this purpose provided with one or several steam jet compressors (boosters).

For this system, firstly the main condenser and its cooling water temperature should be checked and only then, if necessary, its evacuation group.
If the unit has one or more steam jet pre-condensers, then their backpressure, i.e.the pressure in the preceeding main condenser, must first be examined (pressure to be read from the Operating Instructions A12).
If the condenser pressure is correct the fault must be in the compressors (first or second stage).

## 4.0 Abrupt loss of vacuum

At first, check the measuring instruments (recalibrate, if necessary) whether the performance decrease is correct.
Specifically check whether clogged or fractured instrument pipes or water pockets falsify the readings.
Compare the actual results with the specification in the Operating Instruction A 12, resp. 12-3 Pos. 6.4. Under no circumstances may the stated discharge temperature be exceeded, as otherwise excessive back pressure will exist for the ejectors.

If the instruments reading is satisfactory, trace defect !

If the evacuation unit can be isolated from the main condenser, by means of shut-off valve or blind flange, then zero load test should be carried out (see 2.3).

If half the condenser pressure is not attainable, the fault must lie in the evacuation unit, otherwise it is in, or ahead of, the main condenser.

### 4.1 Possible reason

The cooling water (e.g. too little or too warm)

**4.1.1** Check by hand all entry and exit pipes of the condenser to investigate temperature differences and to compare with the Operating Instructions.

If in a direct condenser no differences are observed, but all parts are equally hot, the spray nozzle in this condenser might be partially or totally clogged (see also 7.4)

**Remove the spray nozzle (see 7.5) and clean it.**
**Control the spray angle !**

**4.1.2** If water is passed through the last steam jet ejector (atmospheric stage) the preceeding intercondenser is filled with water. This can be checked by sounding to find out if hollow or not.

**Check the tail pipes in the hot well whether or not the outlets are clear. In barometric installations, check the barometric height. This can change slightly, due to atmospheric condition, but considerably if the water becomes highly aerated as to change its specific gravity (see also 4.1.5).**
**Check tail pipes for rost and leakage.**

Excessive bubbles in the hot well indicate excess gas or air which may original from the process plant.

**4.1.3** Also the tail pipes from surface condensers must be kept free.
If siphons exist to lead condensate between condensers at different pressure, these should be manually checked for partial blockage resulting in the inter-condenser being full or condensate.

To check steam traps, their action can be felt in the following pipework.

**The condenser shall sound hollow when tapped.**

If the surface condensers are drained by pumps, these and their stuffing boxes must also be checked.
Stuffing boxes must have a separate water supply.

**4.1.4** Examine whether the hot well has sufficient buffer volume (especially during the starting period when filling the tail pipes), check also for sludge etc., and clean if required.

**4.1.5** Examine whether the water pressure at the condenser is constant.
Have there been any modifications to the water supply?
Is any other plant fed from the same circuit? Check whether air is entrained in the cooling water pump. This can happen when the cooling water is induced by vacuum.

Look for swells at the suction point and for bubbles in the hot well (see also 4.1.2).

In small direct contact condensers of earlier designs with baffle internals and without spray nozzle, an orifice disc for dosing of the cooling water is clamped between the flanges on the input side.

**Examine whether the orifice disc exists and is clean.**

**4.1.6** Specified cooling water temperatures must not be exceeded. Check the actual temperatures with those given in the manual.

**4.2** Possible reason:

The motive steam
(e.g. too low pressure, too little, too wet or nozzle clogged)

**4.2.1** To check the steam quality all bleed points of the motive steam lines shall be opened. Wet steam will discharge to atmosphere with a white plume.

**Allow to discharge until the plume disappears and the steam flow is constant.**

**4.2.2** Check the motive steam pressure at the nozzle. When normal steam gauges are used, it should be noted that when the steam is shut off, the residual vacuum can act on the gauge and displace the pointer up to 1 bar below zero. Thus the actual pressure could be 1 bar lower than indicated.

**Use a manometer vacuum gauge or remove the stop pin.**
**Check also strainers, siphons, and the longer instrument pipe-lines.**

**4.2.3** Touch the intercondensers and the ejectors themselves. If the intercondenser is at lower temperature than that indicated in the instructions, and no warmer zones can be detected on the vapour inlet and cooling water outlet, this indicates a blocked motive nozzle of the preceeding ejector (see also 4.1.1)

**Then check the motive nozzle, as 4.2.4!**

Provided that the suction flow is air or non-superheated steam, the different zones of the ejector acquire operating temperatures corresponding to their pressures.
Normally suction connections and mixing zones (convergent parts of the diffusor) must be cooler tan the diffusor exit.
At absolute pressures below 6 mbar a non-heated diffusor entrance will also ice-up from outside or at least will be covered with frost.

**4.2.4** It is simple to examine a clogged motive steam nozzle because the nozzle with the steam chest or the bend can be removed. Care should be taken no parts causing a blockage do fall out unnoticed.

**Remove the foreign body carefully without damaging the nozzle throat, ascertain its origin, avoid a repetition!**

**The diffusor of small ejectors should also be visually checked!**

**If a blockage of motive nozzle has been detected, the steam lines should be blow through!**

**4.3.5** Slacken or remove the motive nozzle from the steam chest or the bend, and check the gaskets.

**By-passing motive steam would decrease the suction performance**.

Compare whether  the throat diameter of the cleaned nozzles still correspond to the data given in the Operating Instructions A 12 and M 12-3 under pos. 6.6.

In case of need, twist drills calibrated to tenths of millimeter can be taken as measuring plugs.

## 4.3 Possible reason

Leakage

The suction performance of steam jet ejector is designed according to the maximum leakage air-flow to be expected in the process plant.

After a long operational period additional leakage air can lead to a gradual or also abrupt decrease of vacuum.

The causes can be:

**a) Cracked gaskets.**

**b) Stuffing boxes in valves and condensate pumps whose packing has become dry and leaky. Sealing water for condensate pumps should always be fresh water.**

**c) Corroded tail pipes.**

**d) Erosion of the bend behind an ejector by wet motive steam.**

**e) Where screwed-in motive nozzles are used, thread erosions can lead to steam by-pass.**

**f) Erosion of the condenser at the point of impact of the cooling water (spray cone of the water nozzles) and the impact zone of the steam (only when ejector is mounted horizontally).**

Check by hydraulic test, as under 2.1!

**5.0** Slow but continuous vacuum lost after long-time operation

Change motive nozzles!

Whereas an abrupt decrease of vacuum mostly is caused by a single source of trouble, the low decrease over a period points to the commencement of general wear of the deaerating group and especially at the final stage. Additional to the Instructions 4.1 to 4.3, some special recommendations are given in the following.

**5.1** Again the measuring instruments have to be examined for correct reading. Also instrument lines having become brittle can falsify the reading.

After a period of operation the final stage (to the atmosphere) can be eroded or the discharge line can become polluted on encrusted.
Therefore measure the intermediate vacuum at the measuring socket of the preceding intercondenser and compare with the Operating Instruction A 12 resp. 12-3 (pos. 6.4).

Remove and clean the discharge pipe. Blow out the final stage thoroughly and again measure the intermediate vacuum. If still not in order, then an internal inspection of this ejector and check of motive nozzle and diffusor diameter is indicated.

**If encrusted, clean!**

**If worn, replace nozzle!**

**Check gaskets carefully!**

**Rebore, in case of need, only according to instructions!**

**5.2** In the case of surface condensers as intercondensers the cooling tubes can be fouled or even encrusted not only internally but also externally.
The required intermediate vacuum can no longer be attained,
therefore examine and clean.

**5.3** Also leakage, as under 4.3, may be the cause for slow decrease.

**Examine stuffing boxes and make hydraulic pressure test (see 2.1)**

**5.4** If the external inspection and touching the equipment do not give any indication of the defect, then fit measuring instruments at each stage in order to compare the intermediate vacuums with the data from A 12 resp. 12-3 (6.4).

**Isolate the steam jet ejector from the processing plant, carry out performance test and, if necessary, proceed as 4.1.1 to 4.2.5!**

## 6.0 Varying vacuum

There can be several reasons both internal and external.

**6.1** If the required vacuum is attained, however, the final stage (to atmosphere) wizzles and pulsates, this indicates a lack of suction stream.
This instability can be overcome by adding life steam into the suction line.

**6.2** This pulsation can also indicate a flooded intercondenser.

**Check for scale deposits in the ejector.**
**Examine cooling water pressure and tail pipes.**

**6.3** If a multi-stage steam jet ejector, for example, for 10 mbar, is overdimensioned for its suction flow, the steam jet compressor normally having no heating device, can reach the freezing point 5 mbar or less, a low load conditions.
Then it will alternative between icing and thawing.

**Use heating. If a heating device exists, examine it!**

**6.4** The characteristics of jet ejectors demand that two stages the back pressure curve of the first and suction pressure curve of the second stage overlap sufficiently. If this is not the case, due to changing load conditions, pulsation may result.

**Check vapour and gas flow from the process!**
**Check jet compressors. They should be isolated from the process plant and a performance test made with the jet compressor according to 2.2 at varying loads (see A 3 and M 12-6)!**

## 7.0 Dismantling and Internal Inspection

If the fault is not to be found or localized neither by examination of external and internal influences nor by a programmed performance test, the unit must be dismantled gradually.

**7.1** The serial numbers of the ejectors are stamped in the front of the motive nozzle and on the rim of the diffusor flange.They should be verified.

Begin at the deaerating group (see fig.1) with the atmospheric stage as stated at 4.2.4 and 4.2.5.

In order to determine the wear of boring, take a test plug (shank of twist drill) with a large diameter next to that specified in the Operating Instruction A 12. resp. 12-3, pos. 6.4.

If there are grooves in the throat area of the nozzles, or if these are eroded, spare nozzles must be inserted. Reboring should be carried out in case of need only in accordance with our instructions.

**7.2** The same applies for the diffusors.

Check gaskets in the connecting pipes. Displaced gaskets diminish the performance and may become porous.

**7.3** The internal inspection of the intercondenser comes next and so it is done with the preceding stages until the fault has been found.

**7.4** Where applicable, check the spray angle of the cooling water nozzle in the main condenser.

**7.5** Instructions for the dismantling of jet ejectors and cooling nozzles are given in the appendices pages and of the above mentioned Operating Instructions A 12, resp. 12-3.

**7.6** In the case of jet compressors (booster) existing ahead of the main condenser the motive nozzles and the heating, if any, should be examined first.

## 8.0 Check list and steps to take if vacuum drops

| | | |
|---|---|---|
| 1. Measuring instruments | Check reading and readjust, if necessary | 2.4, 4.0 |
| 2. Operating temperatures | Examination by touch | 4.1.1 |
| 3. Zero load test (shut off) | | 2.3 |
| 4. Motive steam | Pressure decrease | 4.2.2 |
| | Wet steam? | 4.2.1 |
| 5. Cooling water | Lack of, or excess | 4.1.5 |
| | Temperature? | 4.1.1 |
| 6. Air leakage test | | 2.1, 4.3 |
| 7. Ejectors | Strainer | |
| | Motive nozzle clogged? | 4.2.3, 4.2.4 |
| | Motive nozzle eroded? | 7.1 |
| | Diffusor eroded? | 7.1 |
| 8. Final stage ejector | Back pressure at discharge | 5.1 |
| | Erosion? | 4.2.5 |
| | Zero load test! | 2.3 |
| | Instability? | 6.1 |
| 9. Intercondenser | Pressure and temperature | 4.1.1 |
| | Corrosion? | 4.1.1, 4.1.2 |
| 9.1 Direct contact condenser | Nozzle, tail pipe, hot well | 4.1.2 |
| 9.2 Surface condenser | Condensate discharge? | 4.1.3 |
| | Cooling tubes fouling? | 5.2 |
| 10. Main condenser | see point 9 | |
| 11. Jet compressor | Back pressure | 3.0 |
| | (booster) Ice deposits, heating | 6.3 |
| | Encrustation | |
| | Motive nozzle erosion | 4.2.5 |
| 12. Process plant | Leakage? | 2.1, 6.4 |
| 13. Performance test | | 2.2 |
| 14. Unit dismantling | | 7.0 |