

You walk into your office in the morning and the Etracker-OLM screen shows a sudden increase in heat rate earlier in the morning. You immediately know something undesirable has happened but, of course, the question is what.

To assist the performance engineer in moving from knowing there is a problem to identifying its specific cause, Encotech, Inc. has added a library of symptoms of the typical kinds of degradation that occur in an operating power plant, to the Etracker-OLM program.

Each example in the symptoms library contains:

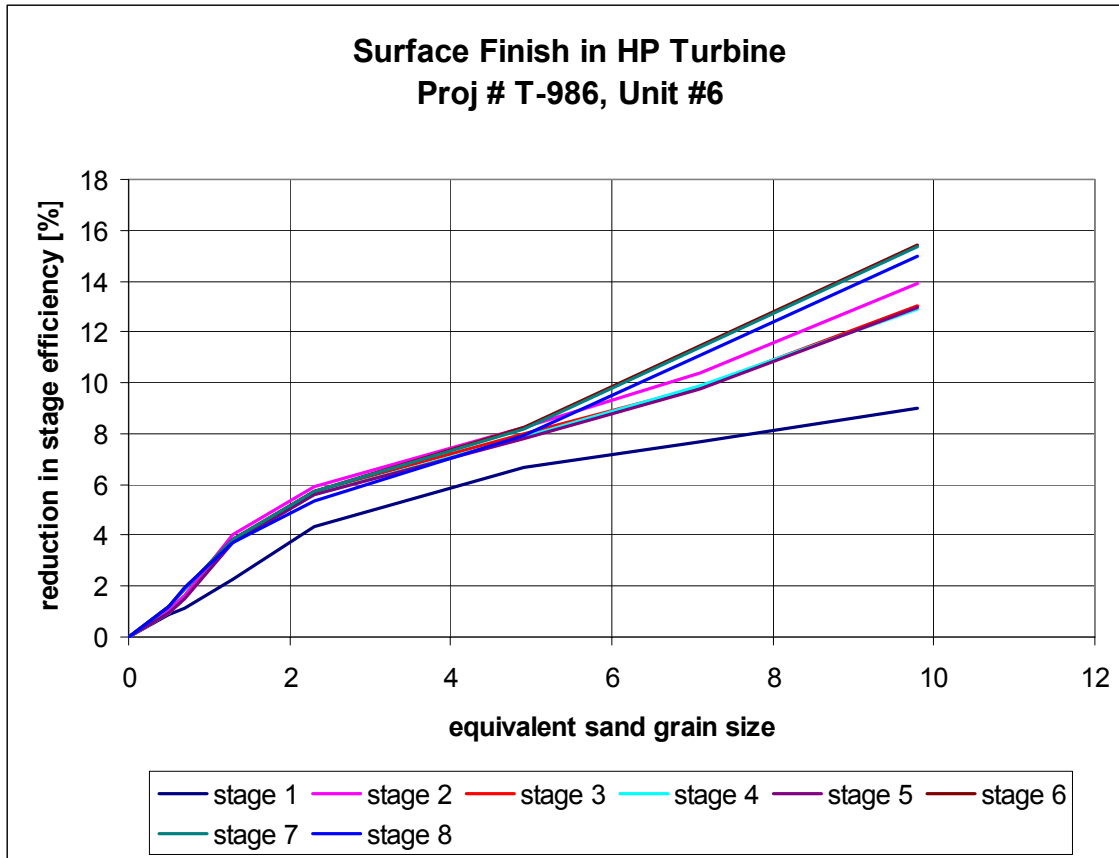
- 1) A description of the problem being evaluated
- 2) A discussion of the typical symptoms, causes of the problem, and their impact on performance
- 3) Graphs showing the impact on heat rate and generator output as a function of the seriousness of the degradation
- 4) A profile of the principal parameters affected by the degradation problem. This can often be helpful in matching typical problem symptoms with the observed profile of the incident being investigated.

The following is an example of one of the items in the Degradation symptoms Library

**Problem: Copper deposits in the HP turbine**

**Assumptions:**

- 1) Deposits build up on all stages of the HP turbine but principally on the second and latter stages. They are assumed to build up in the following proportions:
  - a) 4.8% reduction in area on first stage.
  - b) 17% reduction in area on all remaining stages of the HP turbine.
- 2) The relationship between reduction in stage efficiency and the roughness of deposits is defined by the following curve which was developed using eSTPE and data from the STPE Audit Database.



### Equipment

650 MW, 2,400/1000F/1000F turbine with opposed flow HP/IP turbines in a single outer casing. It is a seven heater cycle.

The model was Diagnostic Model #2

### Symptoms

There are two different situations to be dealt with here.

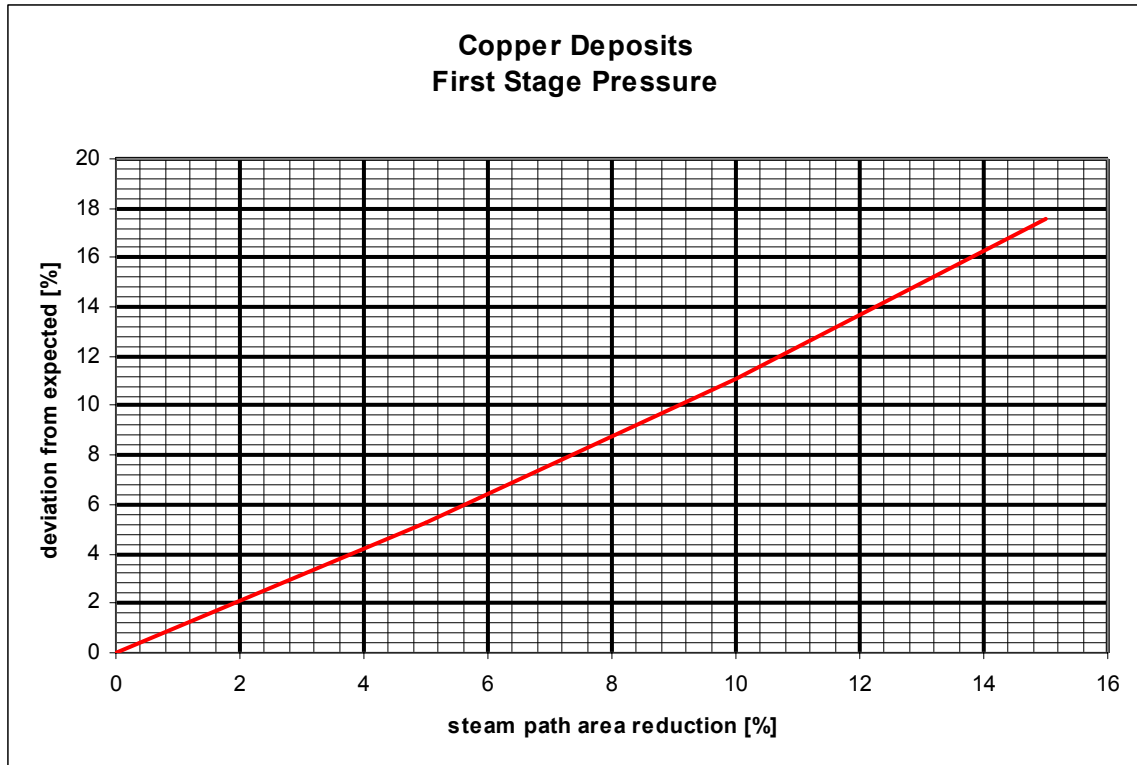
**Situation A** is the set of results generated by Etracker-OLM when operating in its normal mode. For this condition, as the deposits build up, the flow passing capability of the turbine will decrease. The Etracker-Model runs as the new-and-clean machine would run and, since Etracker-OLM matches the measured flow, which has been reduced, Etracker-OLM will have to close its control valves. Situation A is what should be compared with changes in operating “deviation from expected” values and with Operating Degradation Profiles that have been generated to examine trends from one point in time to another.

**Situation B** describes, specifically, what is happening to the Valves Wide Open (VWO) capability of the unit. Etracker-OLM calculates, for each operating point, what the throttle flow would be at the same control valve positions and the same throttle pressure

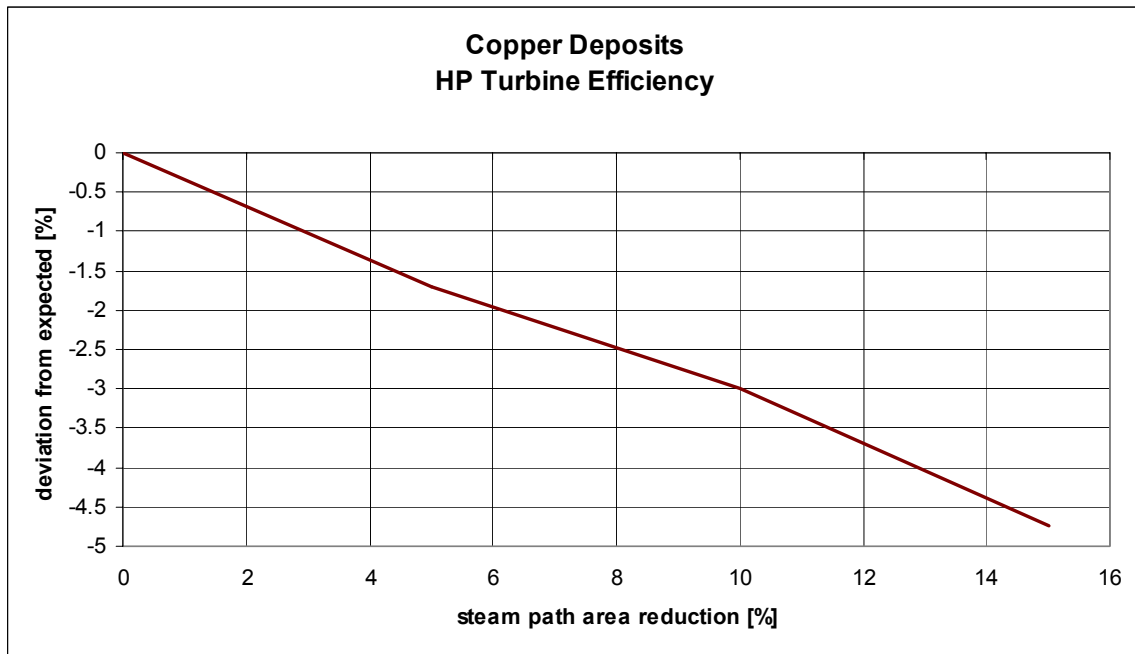
and temperature. This enables the user to determine if the flow passing capability of the turbine has been impacted in any way by changes in steam path geometry.

**Situation A** – The principal symptoms that will be observable from Etracker-OLM trend curves are described in the following graphs.

**Figure 1**



**Figure 2**



**Figure 3**

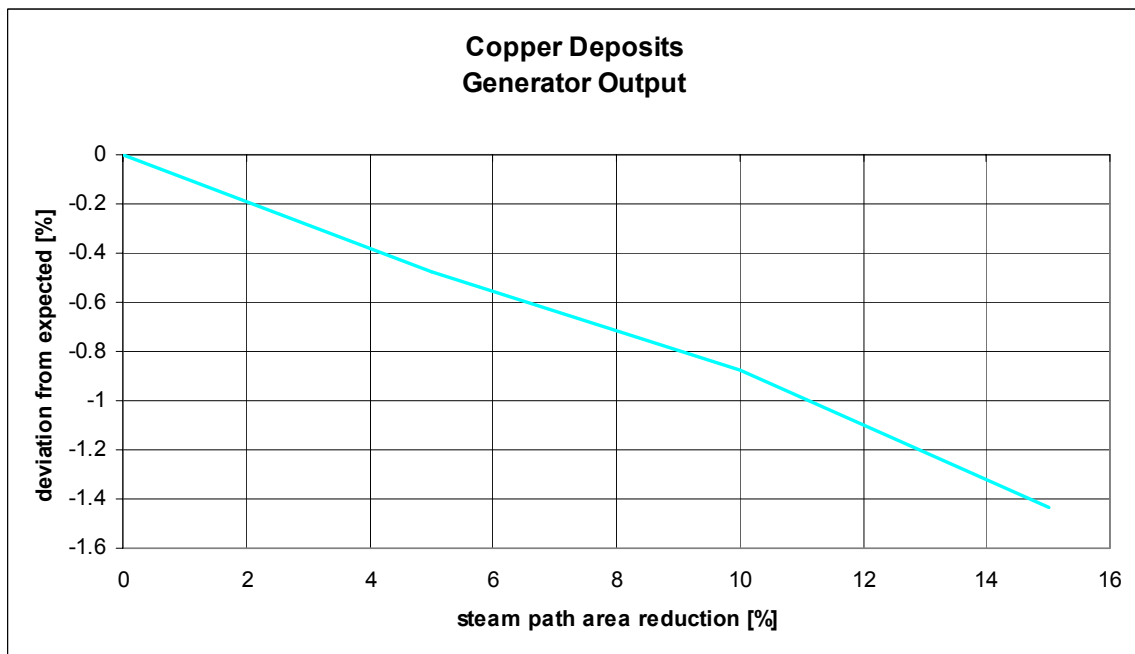
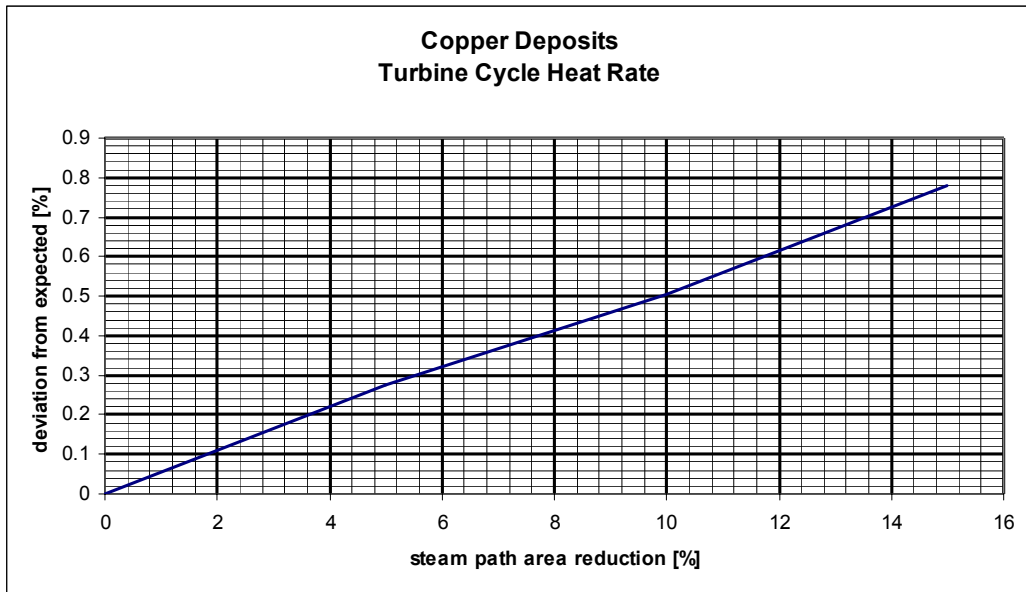
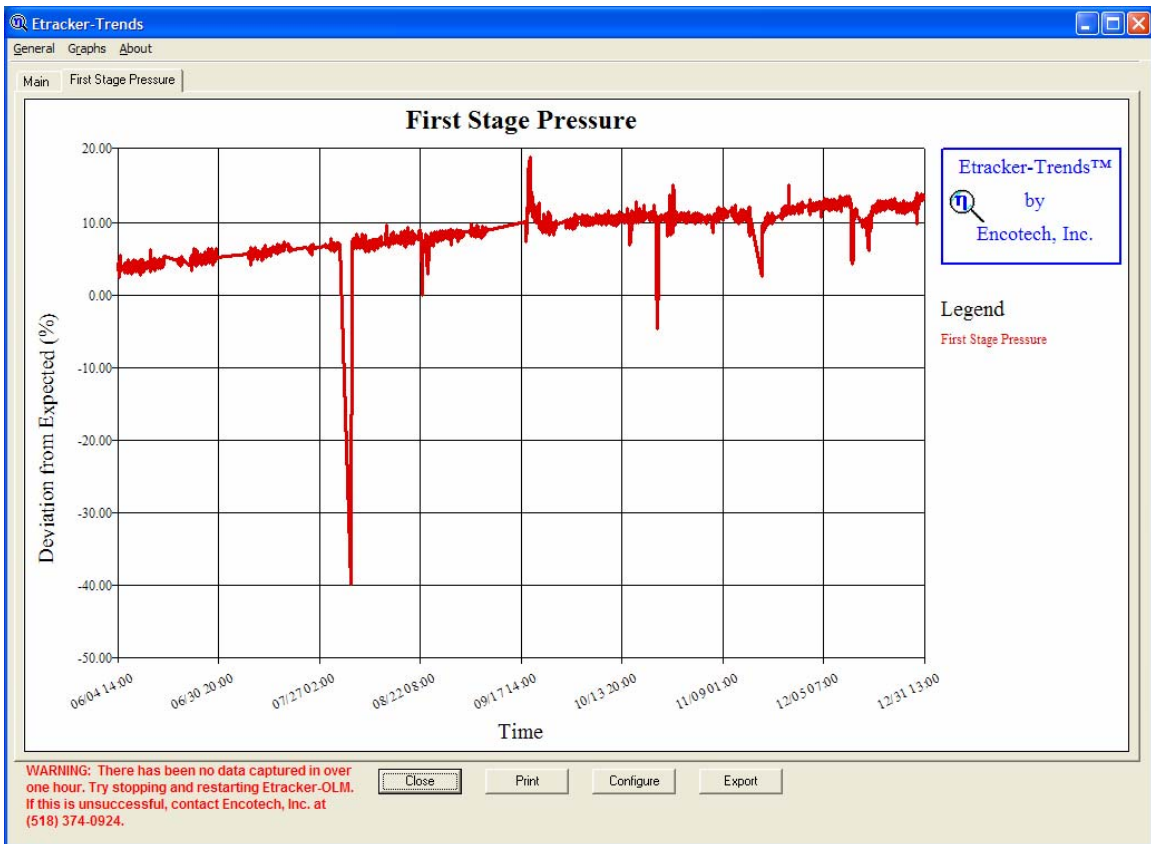


Figure 4



A typical Etracker-OLM trend curve for 1<sup>st</sup> stage pressure, for a seven month period is shown in Figure 5.

Figure 5



## Observations:

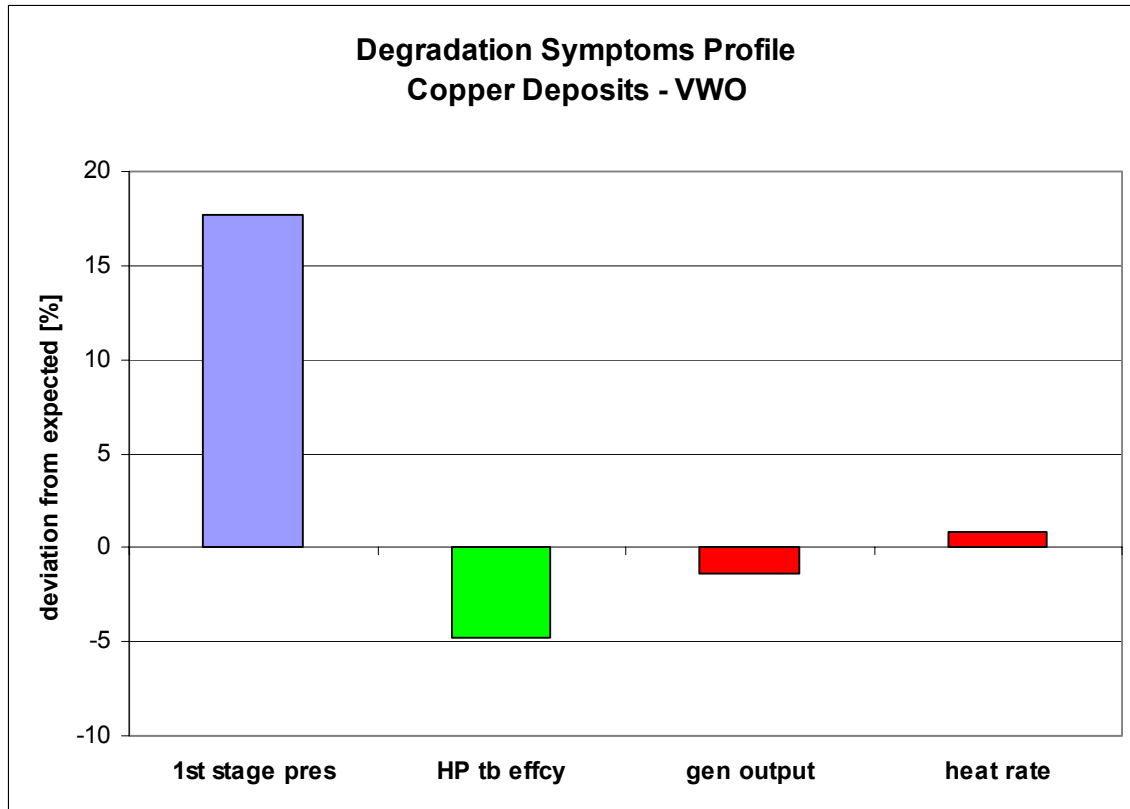
- 1) The most dramatic impact is the rise in first stage pressure. This results from the reduction in steam flow path area downstream of the first stage.
- 2) The next most significant change is the reduction in HP turbine efficiency. The actual decline in HP efficiency is greater than shown in the graph. This is because Etracker-OLM matches the measured steam flow and as the flow diminishes, with increasing deposit thickness; Etracker-OLM must close the control valves to get a flow match. This in turn reduces the HP efficiency of the ideal plant and so the reported “deviation from expected”, which is determined by comparing with a reduced HP turbine efficiency, is less than the actual reduction in HP efficiency.
- 3) As with the reduction in HP efficiency, the actual generator output will diminish more than reported as the “deviation from expected”, because the actual throttle flow is going down but the “deviation from expected” value is determined by a comparison between the measured generator output and that which would be expected at the reduced throttle flow.
- 4) Turbine cycle heat rate increases because of the reduced efficiency of the HP turbine.

## Acceptable matching principal parameters

Principal parameter change: Increase in first stage pressure

## Parameter Profile

Parameter	Deviation from expected [%]
First stage pressure	17.60
HP turbine efficiency	-4.75
Generator output	-1.43
Turbine cycle heat rate	0.78

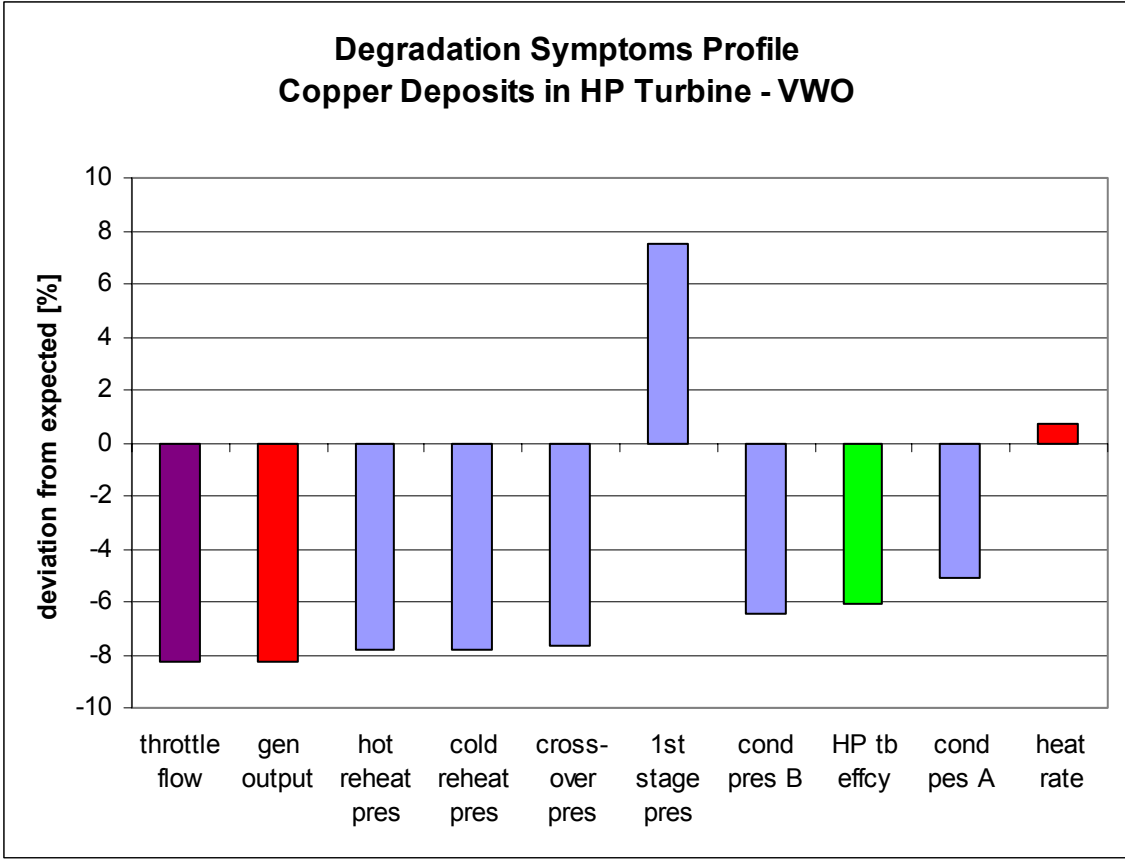


**Constants for use in the equation: value = a + b \* TFR**

Parameter	a	b
First stage Pressure	16.427	1.2625
HP turbine efficiency	0.4721	-5.239
Generator output	0.03	-1.4452
Turbine cycle heat rate	-0.0027	0.8031

**Situation B** – Etracker-OLM, in normal operating mode, matches the measured flow of the turbine, plus throttle pressure and temperature and reheat temperature, and then compares the measured values of other parameters to those that would be expected from a new-and-clean machine. However, in order to gain an understanding about what has happened to VWO flow passing capability, Etracker-OLM also determines, for each set of recorded data points, the throttle flow that would be expected at that current control valve position, and throttle pressure and temperature.

The following profile is an indication of the unit capability at VWO as impacted by the presence of copper deposits. Note that the various extraction pressures have been omitted from the profile, since they would all have “deviation from expected” values similar to the cold and hot reheat and cross-over pressures.



Note that all turbine pressures, except the 1<sup>st</sup> stage, go down because of the reduced flow passing capability.