On-Stream Tightness Testing of Vacuum Process Installations

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DCI Meettechniek.

- DCI was founded in 1988.
- DCI is an independent company specialized in technical services aimed at the processing industry. These services are usually carried out on-site at the client's location.
- DCI performs:
  - (on-stream) leak tightness testing (>25 years)
  - heat exchanger tube inspections (>15 years)
  - valve testing (>15 years)
- has approximately 35 employees
- the shares are (indirectly) owned by RTD and Stork

Primary markets

Our office is located in the south west of the Netherlands.
Our clients are located all over Europe, but often also far beyond this.
**Power Plants and (Petro)chemical Industry**

Many sorts of leak tests are carried out in the process industry. Especially for vacuum systems, a number of testing methods are developed on one's own. Using these techniques, it is possible to find air inleakages with the plant in operation.

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**On-stream leak testing**

- **Air ingress**
  In power plants used, to find air inleakages in turbine- and condenser vacuum systems
  In (petro)chemical industry to find leakages in evaporators and vacuum columns

- **Cooling water leakages**
  In power plants used to find water leakages in condensers

- **Helium Extraction Method**
  Developed for testing heat exchangers in operation
Power plants

Leak test of turbine vacuum system

Air ingress problem analysis

Atmospheric air entering the vacuum causes an increase of non-condensing gases in the condenser.

This can cause:
- a system pressure increase
  - pump capacity too small
  - increase of system pressure
- an increase of Oxygen level in condensate
- a pressure-rise test, which is out of specification
  - performed at specified generator power
  - volume of vacuum system

Also often a preventive leak test is carried out.
- global check before a revision
- after a shut down to check the repairs
Locating air leakages

- Smoke test (chemical smoke source)
  - problems because of the presence of air currents (drafts, ventilation)
  - low test sensitivity
- Ultrasonic detection
  - problems because of surrounding (background) noise
  - low test sensitivity
- Halogen test
  - not allowed any more because of environmental properties
- Helium test

Helium test

Why to use Helium?

- Helium is an inert gas
  - mass 4, only 5 ppm present in the atmosphere
- Not harmful, explosive or corrosive
- Absolute selective measurement for qualifying and quantifying leaks
- Helium does not condensate in the condenser atmosphere
- Best performance at maximum power

Vacuum schedule, power plant
Air ingress localization

When carrying out a leak test on a turbine-condenser vacuum system, the partial pressure of helium in the system, is measured during the complete test. At the same time all potential leak locations like rupture disks, shaft seals, flanges etc. are sprayed from the atmospheric side with helium. Should a leak be sprayed over, an air-helium mixture will enter the vacuum system and cause an increase of the partial pressure of helium. The reaction time, i.e. the time between bringing the helium in contact with the leak and the detection of rise of its partial pressure, is to be determined by experiment. Normally this time is approximately 30 seconds. The detection sensitivity, which differs per installation and per operational situation, can be down to 5 mbar.l/s.
Air ingress localization

Testing of components in insulation

All necessary test equipment, mounted in a Van.

Air ingress testing

-Vacuum pressure depends on:
  - vapour pressure of the condensate at the prevailing temperature
  - condition condenser
  - pressure of non-condensing gases
-Air ingress increases the amount of non-condensing gases and so the vacuum pressure rises
This vacuum pressure rise will cause an increase of system temperature (reduced efficiency).
Air ingress testing

- High presence of non-condensing gases:
  - worse vacuum
  - more pump capacity necessary
- Efficiency lower; higher fuel costs
- Air (Oxygen, harmful components) can cause damage of the installation
- All these problems lead to extra costs or to income reduction

Air ingress testing

- Vacuum system of medium size power plant can be tested in 2 - 3 days
- Efficiency increase depends on size leaks
- Trend:
  - problem solving
  - preventive measurements

Example (1)

- Power plant in Turkey:
  vacuum pump output was 65 m³/h;
  after repair found leak, the pump output decreased to 35 m³/h;
  this resulted in a power increase of 2 MW;

  income difference of $70,000,- per month

Example (2)

Power plant needs both vacuum pumps at full power, to maintain the vacuum. After repair; possibility to stop one pump;
- Direct cost reduction
- Reserve pump capacity available if anything deteriorates
Found leaks

Test equipment
Other techniques.

Principle of helium leak test of heat exchanger in operation. The mass spectrometer is coupled via the extractor (a kind of semi-permeable membrane) to the secondary (low pressure) side of the heat exchanger. In the primary circuit (high pressure side) Helium is injected. A leak will be manifest, when the helium partial pressure increases in the secondary circuit of the heat exchanger.

Benefits of Air Ingress Testing

- Reliable method to localize and quantify leakages; also for insulated vacuum systems
- Better vacuum results in product quality improvement
- Efficiency higher; lower fuel costs
- Air (Oxygen, harmful components) can cause damage of the installation

Air ingress can lead to extra costs or to income reduction