# Refrigerated Ammonia Tank Testing with Acoustic Emission

Acoustic emission testing detects defects and other damage that is 'active' at operating loads. In particular, AE testing is sensitive to cracking or similar damage developing in service.

The benefit of an AE test is that it provides a full, volumetric test of the tank shell while it remains in service. Vessel entry is not required and avoids the costly and potentially damaging process of shutting down a tank and preparing for internal inspection. The test aims to detect and locate areas of concern, follow-up inspection with a complementary NDT method is needed to identify and size any AE indications.

AE testing is listed as an applicable non-intrusive test method in the European Fertiliser Manufacturers Association guidelines. Australian codes also allow AE testing of ammonia tanks in lieu of internal inspection.

## Acoustic Emission and Metal Equipment

Acoustic Emission is high frequency sound from cracks and other flaws subject to increasing stress. For in-service tanks, this means increasing their level by about 5% while recording AE activity.

In the case of new tanks, the stimulus for AE activity is from the standard hydrotest. This test can detect weld defects and localized yielding at hydrotest loads, especially in non-stress relieved vessels.

Although an AE test detects cracking and similar damage, it does not determine the size or exact position of individual defects. The main function of an AE test is to identify localized areas in need of more in-depth inspection or more frequent monitoring.

## Carrying out an AE Test

High frequency (150 kHz) acoustic sensors and specialized instrumentation detect AE activity as a tank is filled. The sensors are placed to cover the entire shell, typically 5-6m (16-20ft) apart. They are usually mounted on waveguides. These are steel rods spring loaded onto the vessel surface to conduct AE signals to sensors on the waveguide ends. Direct mounting of AE sensors is possible in some cases. This has the advantage of greater test sensitivity but is challenging because of the potential for significant ice build-up.

**Waveguide Attached to Cladding**

The AE system is housed ideally within 30m (100') of the vessel and the waveguide mounted sensors are installed at their predetermined locations. Coaxial cables are routed back to the instrument from each sensor. The final step is to check the sensitivity of each sensor and instrument channel.

The number of sensors ranges from 48 for a small 5,000 ton tank to more than 200 for tanks over 30,000 tons.


**Waveguide Screwed to a Coupling on a Double-Walled Tank**

In-service tanks are tested from under 90% to 105% of their maximum operating level for the previous six to twelve months. This may mean operating the tank at reduced level before testing to allow the level increase without exceeding a tank's maximum capacity. A vapour pressure increase may also be needed.

After an initial hold to assess background noise, the level is raised in stages to the test level as shown. One or more load holds (10-minutes each) are incorporated with a final hold of 30 minutes at the test level.


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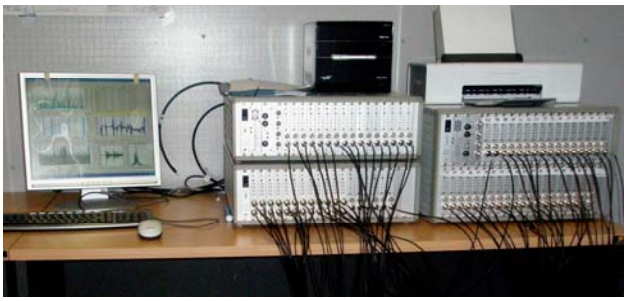

Refrigerated tanks tend to be very noisy, especially during filling. Most of this noise, including operation of the refrigeration system is unavoidable. For this reason, additional load holds may be needed to monitor the tank when noise levels are at a minimum. Ice under the insulation may also be an issue both for mounting the waveguides and as a source of noise during testing.

Sensor and waveguide mounting, tank operating and test levels, whether filling is from the ammonia plant or a ship or other source, estimated fill time and other aspects of testing need to be discussed with IRISNDT personnel well in advance of the test.

AE data is monitored during the test to identify and minimize noise during filling. Further analysis is needed to determine whether there are any areas of concern. IRISNDT often uses wave based pattern recognition[1] to separate fill and any noise from ice from the underlying AE data of interest. This is evaluated in terms of trends of AE activity from each sensor with respect to level and time and intensity. Only AE sources (areas) showing a response to the applied load or are otherwise considered significant should be reported.

## Capabilities

- Test of the tank shell while the tank continues in operation. If required, the roof can also be monitored and tested with a pressure increase.
- Provides information about a tank's response to service loads. Sensitive to defects developing in service. Can also detect fabrication defects in new tanks during hydrotesting.
- Provides approximate locations or areas of sources of AE activity needing follow-up examinations or monitoring. This information is qualified by intensity analysis to help determine the extent and urgency of any inspection work.

## Limitations

- Qualitative assessment only. Does not give an exact measure or location of damage.
- Even with advanced noise discrimination techniques, the areas most affected by fill or other noise may have significantly reduced sensitivity.
- Flaws in low stress areas such as the floor and those that are structurally insignificant will not generate AE.

## Preparation

- Supply vessel drawings and operating history (level, pressure, temperature and so forth).
- Plan the test including the number of sensors, mounting method, access, fill range and means of carrying out the fill test.

## Facilities and Services Needed

- 110V or 240V AC electrical power.
- Level and pressure voltage inputs to the AE system if possible.
- Access for mounting sensors and cable installation.
- Insulation contractors to cut insulation ports if needed for direct sensor mounting.
- Arrangements for carrying out the fill test.

[1] Improving Noise Discrimination for an Ammonia Tank AE Test. British Inst. of NDT Insight Vol 54, No 12 Dec. 2012.

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