LEAK DETECTION IN SEALED GRAIN STORAGES

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ABSTRACT

In Western Australia, a pressure test specification is written into contracts for construction of sealed grain storages or sealing of existing structures. On the occasions where the specification is not reached it is necessary to be able to detect the unsealed areas, the leaks, so that they can be rectified. Various methods have been tried for this, but no general system has yet been developed that is completely satisfactory. Methods tried include use of fluorescent dusts, smoke testing, tracer gas use, detection by sound, thermographic systems and soap testing. To date, soap testing has been found to be the most effective system, detecting many leaks not obvious by inspection. After rectification of leaks found by soap testing, the structures under test, silos and large horizontal storages are usually satisfactorily sealed. The use of the various methods is described.

INTRODUCTION

A contract for the sealing of a storage will have included in its text a method of assessing the degree of seal achieved and a standard above which the contract completion is acceptable. It is also advisable to include a period of time where maintenance of the seal to that standard remains the responsibility of the contractor. This period in Western Australia is 5 years. The life of the seal beyond that period is a function of the durability of the material used as the sealing membrane, the thickness of the seal coat applied, the perfection of the application and to some extent the stability of the storage structure.

It is inevitable that at some time the seal on the storage will no longer be adequate and the treated storage will not pass the sealing assessment test (eg. a pressure test). The problem may occur during the initial sealing attempt or may arise during subsequent use of the system. In either case it is necessary to have some simple, efficient procedure for location of leaks and imperfections in the overall seal so that they can be treated and the sealing of the storage brought within specification.

In Western Australia, we have tried several methods of leak detection for storages with varying degrees of success. This paper summarises our experience to date. As yet we have not found a universally applicable system.

METHODS OF LEAK DETECTION

There is a wide variety of possible approaches to the problem of detection of leaks in an imperfectly sealed grain storage. After rectification of those faults obvious from visual inspection, it has been our experience that storages often may still not meet our pressure test standard (typically pressure decay of 200 Pa to 100 Pa in 15 minutes) although they may come close to it. In many cases, the success of a sealing contract appears to depend largely on the experience of the contractor and his workforce. Even then the seal may be unsatisfactory. Several methods have been used to detect the remaining leaks in the fabric of the store to be sealed.

Fluorescent Dusts

Fine fluorescent dusts are available (SWADA [London] Ltd or in Australia Abel Lemon and Co Pty Ltd) in a number of different colours. These can be used as tracers to detect leaks. The structure under test is pressurised with a fan and the dust fed into the fan inlet. The dust disperses through the structure and is expelled through the imperfections in the fabric. The outside of the structure is then inspected under a near ultra-violet light ('black light'). The imperfections are indicated by the easily seen fluorescence of the dust adhering around the region of the leak. After a further attempt at sealing the process can be repeated using a different colour of dust to check if the treatment has been effective.

The process requires a substantial pressure differential to force the dust through fine leaks, typically about 2 kPa is used, and thus is unsuitable for use in sheds. We have had some success in detecting leaks in concrete cells using these dusts.

Smoke Testing

Smokes can be generated within a partially sealed system and the leaks detected by the emission of smoke. The smoke can be produced by various means (eg. a 'swing fog' unit or by burning flares or smoke bombs).

We have found this method useful as a means of demonstrating the gas loss that can be expected from small, unsealed structures (eg. 15 tonne farm bins), but it has not been effective on larger, partially sealed systems. Since it operates under very low pressure, the results are influenced by wind and smoke only will issue from leaks in the negative pressure, leeward side of the structure. Leaks to windward are not detected. It suffers from one major disadvantage: the residues from the smoke present a possible contamination hazard and must be washed from the store before it is filled with grain.

Tracer Gas Systems

Any gases easily detectable in the field can be used to find leaks. The system under test must be pressurised slightly if all leaks are to be located. Under natural conditions, gas within a structure will only issue from leaks under negative pressure with respect to the external atmosphere.

This method is somewhat cumbersome and costly, though it can be quite effective. It may find leaks difficult to trace by other means such as those through the ground from the floor of the storage that may issue into the open air some considerable distance from the leak in the fabric itself. The main drawback is that analysing instruments need to take a sample for identification. This requires close and detailed attention to all potential leak areas. Furthermore, the immediate dilution of gases when released to the atmosphere make the detection of small leaks difficult. Leaks from storages under phosphine may be detected initially by smell and then located using gas detecter tubes (eg. Drager tubes).

Audio Detection

A pressure differential forcing air through a restriction may make a sound detectable to the normal ear. Typically a pressure differential of at least 200 Pa is required to make leaks hiss or whistle. Many leaks can be detected in this way and this test is our most commonly used preliminary method of checking for leaks. Very small and large leaks do not make an audible noise and are thus not detected. The test is best carried out in the later part of the night when conditions are usually very still and quiet.

We have tried to increase the sensitivity of this method using directional microphones and amplifiers to pick up the sound but with little success. The sounds of nature, while fascinating, detract from the value of the amplification.

Thermographic Survey

We have attempted to use infra red detection equipment to locate leaks remotely. A scanning device which detects infra red radiation from thermal energy on an object surface and converts this into an electric signal is directed to the storage under test. A monitor presents the information detected by the scanning device onto a T.V. type screen. The differential intensities of infra red radiation received can be readily identified. Various methods of information presentation are available and the greatest problem is the interpretation of that information.

While not immediately successful, it is intended to further investigate the potential of thermography in the near future. Among these potentials are:

a) Use of long focus lenses to study inaccessible parts from ground level equipment.

b) The use of colour thermograms to provide a much greater sensitivity to thermal differences.

c) The infra red absorption band of CO_2 makes this gas detectable with available equipment and provides the opportunity of combining tracer gas leak finding systems with actual controlled atmosphere application.

Soap Bubble Systems

If a detergent/water mixture is sprayed onto the surface of an imperfectly sealed storage that is under slight positive pressure (eg. 200 Pa), bubbles form over the leaks. A mixture of 2% household detergent in water has been found satisfactory for the process. The test is best carried out under windless conditions. It is capable of detecting both large (eg. 10 mm^2) and fine leaks (eg. concrete porosity).

This system has been found particularly useful for the location of leaks remaining in horizontal stores after a first attempt at sealing and after rectification of those imperfections detected by inspection or sound. Finding and marking of the leaks remaining in a 25,000 t store takes about 8 man hours. One person is required to operate the spray equipment, while another carries out close inspection of the surface to see bubbles from small leaks.

Figs 1 and 2 show soap testing of a storage in progress.

DISCUSSION

All the leak detection methods described above have been tried by Co-operative Bulk Handling Limited in their recent sealing programme on horizontal sheds. None have been discarded as useless and particular methods are used for different situations. The soap test method has proved to be the most useful and is now routinely used after a sealing attempt on a storage to detect any imperfections in the coating.

Although these methods have proved successful there is still a need for a remote sensing system capable of detecting leaks in a large structure from ground level and providing a measure of the significance of the leak. It is hoped that some form of radiation sensing such as the infra red thermography may provide this answer.

Figure 1. Detergent solution being applied to the roof of a newly sealed storage.

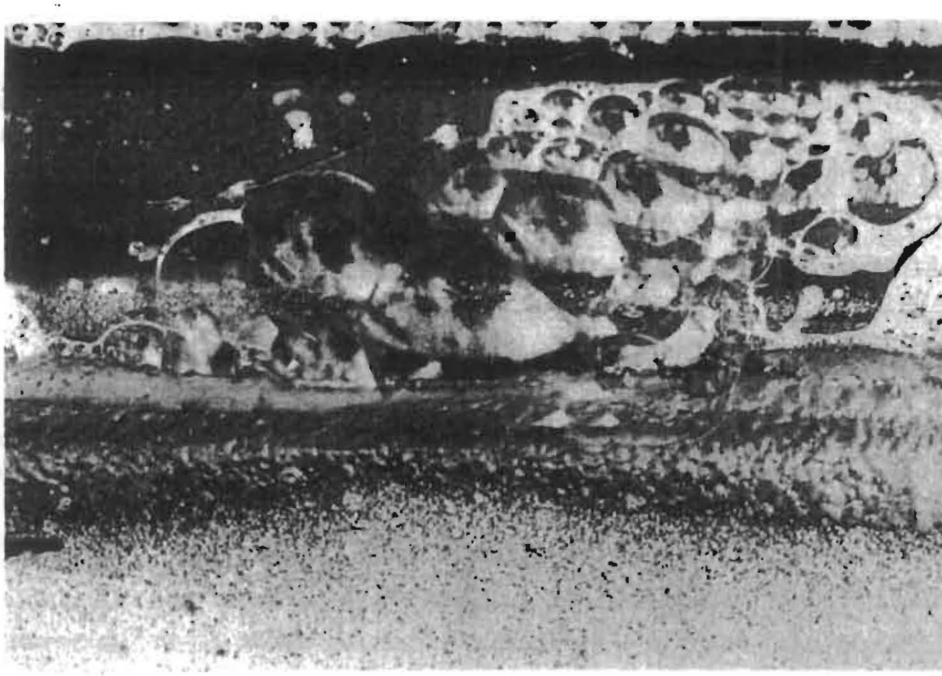

Figure 2. Bubbles developing around a leak in an imperfectly sealed storage that is under slight positive pressure and has been hosed with detergent solution.