WESTERN AUSTRALIAN STUDIES OF SEALING HORIZONTAL STORAGES IN 1980-1982

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ABSTRACT

Sealing studies on three 25,000 tonne (t) horizontal storages were conducted in Western Australia in 1980. These studies included the evaluation of three different sealing materials, pressure testing of empty and loaded storages, and tests on the feasibility of using phosphine or carbon dioxide in these storages for insect control. Additional research was conducted in dust extraction during inloading and outloading and on the effectiveness of heat reflective coatings to prevent pressure buildup.

These studies were considered successful, so 20 additional storages ranging in size from 19,100 to 34,000 t were sealed in 1982. Many of these storages exhibited a higher degree of sealing than those sealed in 1980 and this programme was considered a success.

INTRODUCTION

Interest in the use of controlled atmospheres for insect control in stored grain in Australia prompted field trials on the use of nitrogen in several types of grain storages in the early 1970's (Banks and Annis, 1977). In the early portion of these studies it became obvious that rigorous sealing of these structures was necessary to prevent excessive gas loss. In the late 1970's and early 1980's studies on the use of controlled atmospheres shifted from the use of nitrogen to the use of carbon dioxide and research continued on sealing and pressure testing to determine the degree of gastightness of these storage structures (Banks and Annis, 1980). During this period it was also discovered that conventional fumigants could be used more efficiently and economically in sealed storages.

Co-operative Bulk Handling Limited, Perth, Western Australia, became interested in the sealing programme, particularly in horizontal storages. This paper describes some of the sealing techniques, pressure testings and other studies conducted in three horizontal storages. These studies eventually lead to the sealing of 20 additional storages having a total capacity of 458,400 tonnes by 1982.

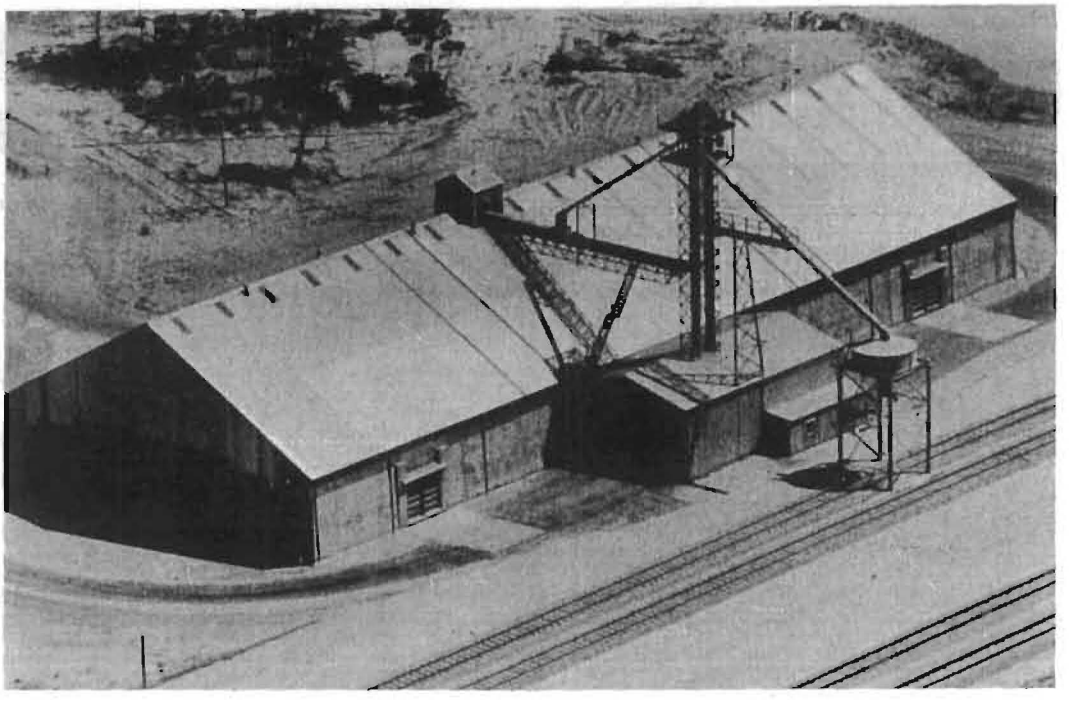
METHOD AND MATERIALS

1980 Trials - Site Selection and Sealing Materials

In 1980 Co-operative Bulk Handling Ltd of Western Australia embarked on a trial programme to seal three horizontal grain storages to determine the

suitability of this technique for improved insect control and quality preservation of grain. Three sites selected were located at Southern Cross, Burracoppin and Cunderdin. A 25,000 tonne (t) storage at each of these sites was sealed using Wastolan (a chloroprene latex based emulsion), Envelon (P.V.C.) and Polyurethane foam.

These horizontal storages measured 133m long by 30m wide with concrete walls 5m high. The side walls are extended a further 1.4m by non load-bearing curtain walls of corrugated steel sheeting and each end wall is topped by a gable-end reaching to the apex of the roof. The roof of overlapped corrugated iron sheeting is supported by steel trusses bolted into the concrete walls and pinned at the apex. The height from floor to roof apex is 14.7m and from floor to the peak of the grain when filled was ca. 11.3m. Each storage has three ground level double access doors each measuring ca. $3m^2$.



"A" type horizontal silo. The gable end and curtain walls above the concrete walls are of corrugated galvanised iron. Three main access doors are provided.

The total volume of each of these sites is $45,300m^3$ and the grain mass takes up ca. $28,300m^3$. The intergranular space of the grain is estimated to be $11,300m^3$ and the head space above the grain is ca. $16,990m^3$. Therefore,

the total free air space in these storages is ca. 28,300m^3 when filled with grain.

These storages are located in an area of Western Australia which has a mean Summer temperature of from ca. 34 to 17°C (day-night) and a mean Winter temperature of from ca. 17 to 14°C. Mean rainfall at these three sites range from 281 to 396mm a year.

1980 Trials - Gas Recirculation System

A recirculation fan was placed on each end of the storages adjacent to an access platform. These fans were located 6m above ground level and were connected to a central duct of 150mm P.V.C. piping running along the floor the length of the storage. This system was designed to pull carbon dioxide (CO_2) out of the grain and redeliver it into the head space when the grain is being treated with the gas. These fans were also used to vent the gas out of the storage after treatment with CO_2 or fumigation with Phosphine gas (PH_3). The venting system was added by fitting another pipe on the discharge side of the fan. When ventilating the storage the discharge side of the return head pipe is blanked off and the fans operated in reverse.

The fans which are described in 1980 trials - Pressure decay tests and dust sampling studies - were also used in the venting of fumigants.

1980 Trials - Pressure Decay Tests

Pressure tests were performed before harvest on empty storages and after harvest on filled storages to determine the degree of gastightness of the facilities. Presure tests prior to harvest were performed so that any leaks present could be repaired from the inside prior to loading. After the bins were loaded a final pressure test was performed. The test criteria established was based on pressure created by running the fans until 180 to 200 Pa pressure was obtained in the storage. At this point the fans were shut down and blanked off. If this pressure decayed by over one-half in 15 min. or, for example, from 180 to less than 90Pa the storage was not considered adequately sealed and further sealing was accomplished. These fans were rated at 85m^3/min and were 482mm in diameter.

Pressure decay tests were generally conducted in the evening as the pressure decay is directly related to the volume of grain in the storage, the climatic conditions at the time of the test and the number of leaks within the storage.

1980 Trials - Dust Sampling Studies

The fans located in the end of the storages were used to vent breathable dust, or dust below 10 microns in size during outloading. Since the fans were

reversible the operators could, depending on wind direction, direct the air flow into the storage to create a through draught or use them to extract the dust.

Additional studies on dust extraction were conducted in 1981 and 1982 to determine if an additional fan located in the centre of the storage was necessary to adequately remove the respirable dust. Results showed a centre fan was necessary and further trials are being conducted into the size and rates.

1980 Trials - Phosphine Fumigation Studies

In 1980 two PH_3 fumigation trials were conducted at Southern Cross and Burracoppin and one at Cunderdin. One of the trials at Southern Cross is not considered here since the instrument used for analysis of the concentration was found to be faulty. In each test 5 gas sampling lines were placed in the storage, four down in the grain mass and the fifth in the headspace above the grain.

Table 1 presents data on the amount of wheat treated in the 5 tests, the amount of aluminium phosphide tablets used in the equivalent dosage of PH_3 evolved in these tests.

Table 1. Treatment of wheat with PH_3 in sealed horizontal storages in Western Australia, 1980.

STORAGE SITE	WHEAT TREATED (t)	Al P. USED Kg	PELLETS /t	$g/PH_3/m^3$
SOUTHERN CROSS	25,351	25	1.6	0.25
BURRACOPPIN I	26,560	21	1.3	0.20
BURRACOPPIN II	26,560	25	1.56	0.24
CUNDERDIN	22,464	25	1.8	0.28

The length of treatment ranged from 10 to 20 days in these studies.

1980 Trial - Carbon Dioxide Treatment Study

One test was conducted on the use of CO_2 in a sealed storage in Cunderdin. In this test 25,000 t of wheat was treated with 48 t of CO_2. The purge time was 27 hrs and the CO_2 was maintained, with the recirculation system operating, for 24 days. The Australian recommendation for control of stored product insects is the maintenance of a CO_2 concentration of more than

35% for a period of 10 to 14 days. Sampling points in this test were in the same locations as those in the PH_3 tests.

1980 Trials - Heat Reflective Coatings

A two week study was conducted to evaluate the effectiveness of a white roof at Southern Cross with a conventional galvanised roof at Bodallin in reducing the temperature inside the horizontal storage. These tests were performed in December when a very high ambient temperature is encountered in this region (see Table 3).

1982 Trials - Sealing and Pressure Testing

The success of the 1980-81 trials on the three horizontal storages prompted C.B.H. to proceed with the sealing of 20 additional horizontal storages in 1982. These storages range from 19,100 to 34,000 t capacity and are located in different grain growing areas of Western Australia. Of the 20, six were sealed with chloroprene latex two were sealed with modified acrylic-vinyl chloride, one with P.V.C. and the remaining eleven with an elastomeric acrylic coplymer. Pressure decay tests were conducted on all 20 of these storages prior to loading and additional sealing was performed on those that did not meet the half-life decay value established in the 1980 studies.

Information developed in many pressure decay studies conducted in 1980-81 showed that the best time to conduct these tests was between 2 and 3 a.m. So the 1982 tests were carried out during these early morning hours to take advantage of the stable conditions.

RESULTS

1980 Trials - Site Selection and Sealing Materials

The three storages selected, although of similar construction, were situated at three different locations. Three different sealing materials were used which provided useful information for the 1982 sealing of 20 additional horizontal storages.

1980 Trials - Gas Recirculation System

The gas recirculation system functioned adequately in maintaining the CO_2 concentration in the grain mass in the study at Cunderdin. The fans also worked well in venting PH_3 from the storages at the completion of the four tests.

1980 Trials - Pressure Decay Tests

The inital pressure decay tests provided insight into pressure changes

in sealed bins during diurnal temperature changes. Figure 1 shows pressure decay rates at the three sites in tests conducted in March and April while the bins were cooling. This figure illustrates the fact that the storages were not sealed to the criteria established for a well sealed bin in that the pressure decayed by more than one-half in less than 15 min. This figure also shows that the storage at Burracoppin was more tightly sealed than were the other two storages.

Figure 2 shows pressure decay times for these storages while they were heating in the morning. Although the decay rate decreased approximatley 30%, only the Burracoppin storage approached the criteria set for a tightly sealed storage. The time was ca. 12 min. for a decay rate of from 200 to 100Pa.

1980-82 Trials - Dust Sampling Studies

During the outloading of the 1981 harvest, dust samples were collected in air space of the three sealed storages. The fans on the ends of the storages were operated according to the prevailing winds and grain dust concentrations were generally found in samples taken from the centre of the storages so further tests were conducted to determine if an additional fan was needed in this area.

These tests were run during filling of the sealed storages and a comparison was drawn between air-borne dust samples taken from these storages and samples taken from two similar unsealed storages. Grain dust concentrations from the centre of the sealed storages ranged from 100 to 226 mg/m^3 while samples from the ends of these storages ranged from 27 to 150 mg/m^3. Samples from the centre of the two unsealed storages ranged up to 593 mg/m^3 while samples from the ends of these storages ranged from nil to 82 mg/m^3. These results confirmed that a centre fan was needed in the sealed storages and they were installed at Southern Cross, Burracoppin and Cunderdin.

In studies during filling in 1982 at Southern Cross and Burracoppin the quantity of dust in suspension in the centre of the Southern Cross site was 500 mg/m^3 with the centre fan off and 300 mg/m^3 with the centre fan on. A similar reduction in grain dust was observed at Burracoppin where the concentration was 156 mg/m^3 with the centre fan off and 60 mg/m^3 with this fan in operation.

Based on this information all sealed sites were equiped with 3 fans and the size of each increased to provide 180 m^3/min of total air flow.

1980 Trials - Phosphine Fumigation Studies

The PH_3 fumigations described in Table 1 were conducted for periods of

from 10 to 20 days. Table 2 presents data on the PH_3 concentrations attained and maintained during these tests.

Table 2 PH_3 concentrations in p.p.m. attained and maintained during fumigation of sealed horizontal storages containing ca. 25,000 tones of wheat

	RANGE OF PH_3 AFTER INDICATED DAYS (D) - P.P.M.			
LOCATION	1D	4D	7D	12D
SOUTHERN CROSS	50-70	55-70	53-70	50-55
BURRACOPPIN I (a)	0-100	32-108	80-150	68-84
BURRACOPPIN II	40-60	60-88	77-90	70-90 (b)
CUNDERDIN	50-100	80-98	63-78	60-80

a) Concentrations of 20-30 p.p.m. after 20 days.

b) 10 day readings

All four fumigations trials at the three locations showed that the necessary concentration by time values for successful insect control using PH_3 were maintained. The value of sealing can be seen in the second test at Burracoppin where 20 to 30 p.p.m. of PH_3 was detected in the grain 20 days after the application of the fumigant. Distribution of the fumigant was generally similar at all sampling sites in the grain mass. The concentrations in the headspace were generally higher.

1980 Trial - Carbon Dioxide Treatment Study

In this trial in the sealed storage at Cunderdin the CO_2 concentrations at all sampling points (except the headspace) was 88 to 100% two days after initial application. The concentration dropped to ca. 60% at all sampling points in the grain after four days and to ca. 45% at these points after 10 days. The CO_2 concentration was ca. 34% after 20 days at the in-grain sampling points and dropped to ca. 24 to 28% after 24 days. The concentration of CO_2 in the headspace fluctuated from 44 to 15% during the 24 day treatment. This was apparently due to diurnal temperature changes creating pressure in the headspace which caused the CO_2 to move about in this area.

This test again provided a graphic illustration of the value of sealing of these horizontal structures since the initial CO_2 applied was still in the grain mass at a lethal concentration (more than 35%) 21 days after the start

of the test.

1980 Trials - Heat Reflective Coatings

The temperature differences found inside the storages between the white roof at Southern Cross and the conventional galvanised roof at Bodallin are shown in Table 3.

Table 3 Temperature differences (^{o}C) found inside a sealed storage with a white roof (Southern Cross) and inside a storage with a galvanised roof (Bodallin). Temperature readings taken at 2 p.m. on 3 successive days in December, 1980.

DAY	SOUTHERN CROSS*				BODALLIN*			
	A	B	C	D	A	B	C	D
1	36	26	30	38	36	54	53	38
2	32	30	35	36	30	47	47	30
3	28	28	31	30	24	43	42	27

* A : outside storage in shade; B : inside storage under skylight; C : inside storage not under skylight; D : outside storage in sun.

This Table shows -

Temperatures were 23 to 28^{o}C. lower on Day 1 inside the sealed storage in the headspace at Southern Cross than were those temperatures at Bodallin. Similar differences can be seen on Day 2 and Day 3 and point out dramatically the value of the reflective coating in preventing temperature build up and subsequent pressure build up in sealed storages.

1982 Trials - Sealing and Pressure Testing

Fifteen of the 20 storages were found to be sealed to a high degree of gastightness. The remaining five sites required additional work to bring them up to these standards. Figure 3 shows results of pressure tests on four of these storages. Each storage was sealed with a different material and this Figure shows that the pressure decayed only 27 to 36% in 15 min. or much less than the 50% decay criteria established for a well sealed storage.

CONCLUSIONS

The 1980 sealing trials proved that horizontal grain storages in Western Australia could be sealed to a relatively high degree of gas tightness. Studies provided valuable information which was used to seal 20 additional storages to a high standard. These storages can now be fumigated with very low concentrations of PH_3 to obtain a high level of insect control. Carbon dioxide can also be used efficiently and effectively in these storages to accomplish the same goal.

The tests also provided valuable information on grain dust extraction during loading and outloading and on the value of heat reflective coatings to prevent excessive pressure build up during diurnal temperature cycles.

REFERENCES CITED

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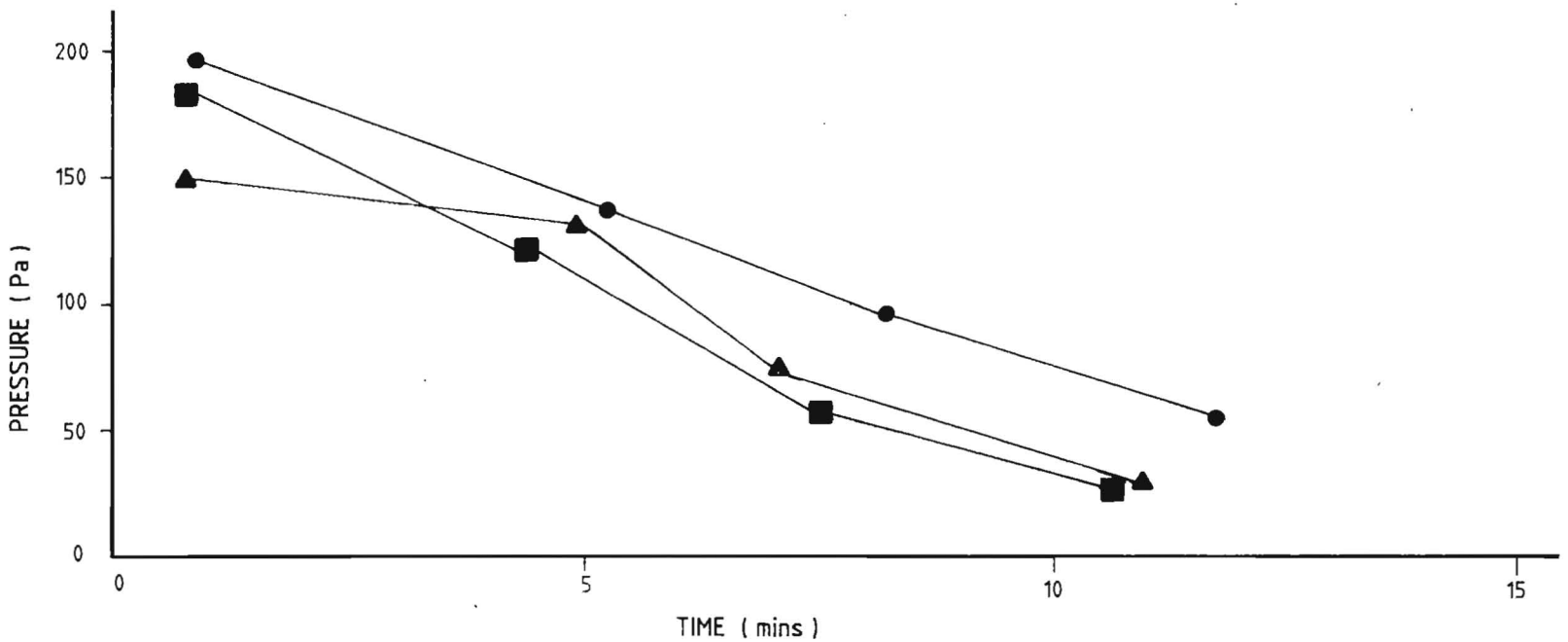

FIG. 1 PRESSURE DECAY TESTS IN 3 25,000 + HORIZONTAL GRAIN STORAGES AFTER HARVEST. TEST CONDUCTED IN MARCH AND APRIL AT EITHER 21.30 OR 22.5 h (STORAGE COOLING)
STORAGE LOCATION : ● BURRACOPPIN
▲ CUNDERDIN
■ SOUTHERN CROSS

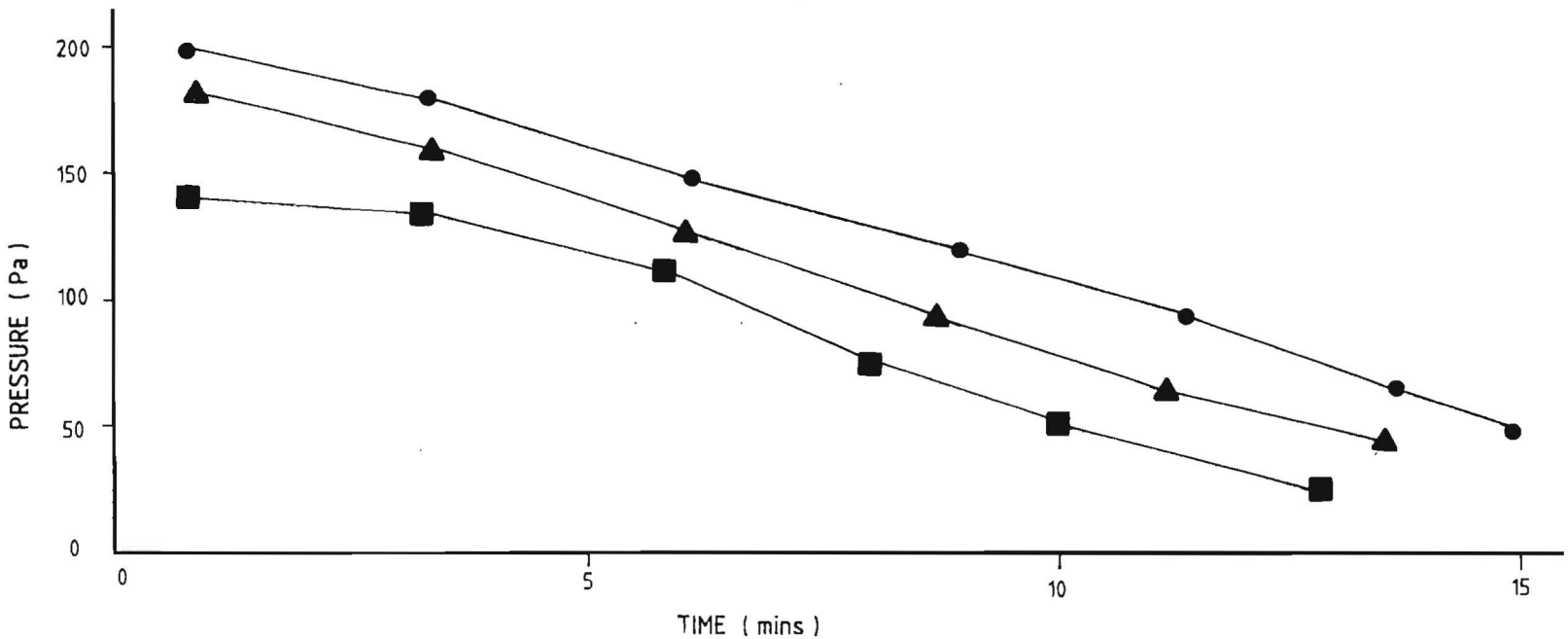

FIG. 2 PRESSURE DECAY TESTS IN 3 25,000 + HORIZONTAL GRAIN STORAGES AFTER HARVEST. TESTS CONDUCTED IN EITHER MARCH OR APRIL AT EITHER 1200 OR 1400 h (STORAGE HEATING).
STORAGE LOCATION : ● BURRACOPPIN
▲ CUNDERDIN
■ SOUTHERN CROSS

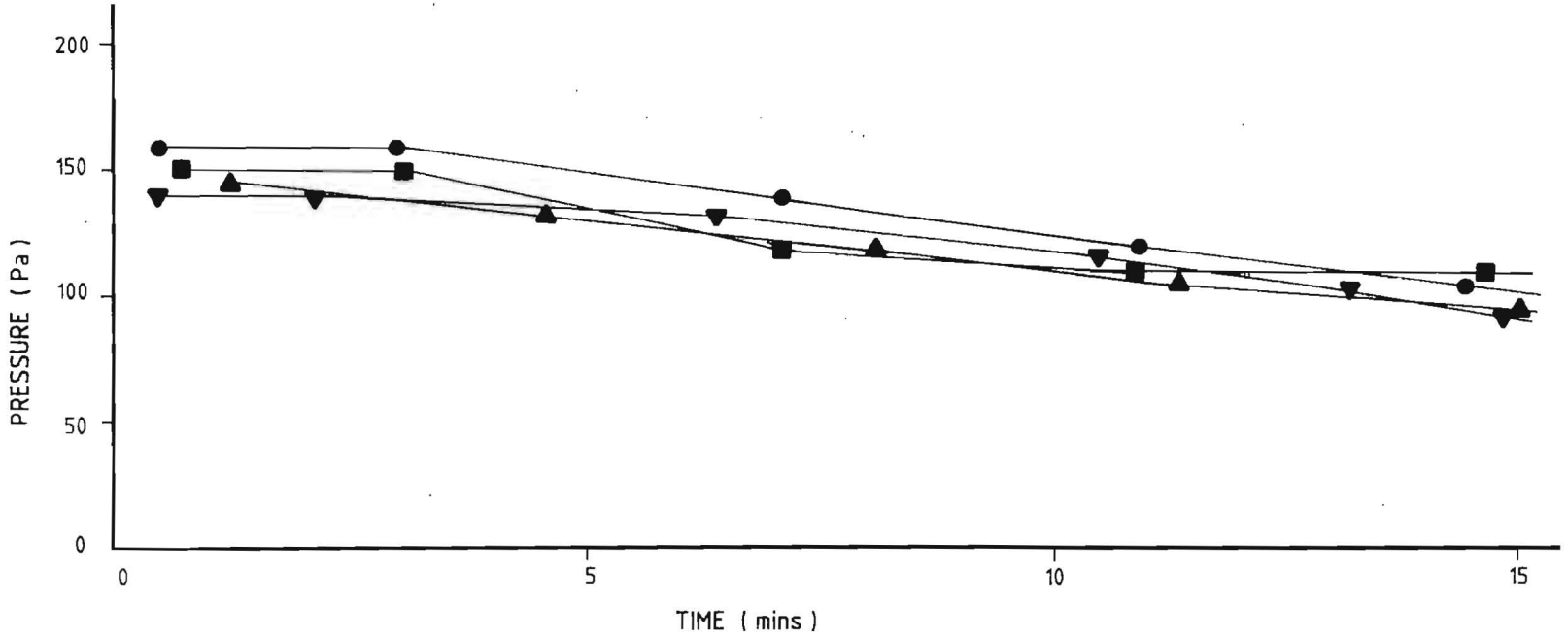

FIG. 3 PRESSURE DECAY TESTS IN 4 19,000 TO 27,000 + HORIZONTAL GRAIN STORAGES AFTER HARVEST. TESTS CONDUCTED IN SEPTEMBER TO NOVEMBER AT 0200 TO 0300 h (STORAGE STABLE).
STORAGE LOCATION AND SEALING MATERIAL :

- ● ONGERUP (P.V.C.)
- ■ KELLERBERRIN (CHLOROPHENE LATEX)
- ▲ MOORA (MODIFIED ACRYLIC - VINYL CHLORIDE)
- ▼ SHACKLETON (ELASTOMERIC ACRYLIC COPOLYMER)