WASHINGTON STORAGE STRUCTURES - WHAT ARE THEY LIKE?

by
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INTRODUCTION

The necessity of maintaining high-quality potatoes over an extended storage period has resulted in an increased emphasis on the proper construction, equipment, and management practices of potato storage facilities. When planning new storages or evaluating existing ones some of the design criteria to be addressed are:

1. Structural integrity, such as adequate strength, durability of materials, tight construction, and low maintenance.

2. Adequate insulation in the walls and ceiling to control heat gain or loss and to control condensation.

3. Adequate vapor barriers in the walls and ceiling to keep the moisture out of the insulation, structural members and wall cavity.

4. An efficient ventilation system to provide uniform air distribution over the entire storage and to maintain high humidity levels.

5. An automatic control system to maintain accurate temperature and humidity levels at all times.

In December 1987, the Agricultural Engineering Department at Washington State University in cooperation with the Washington State Potato Commission conducted a potato storage survey. The objective of this study was to obtain information about (1) design and construction of potato storages in Washington, materials and equipment used; (2) the storage environment provided for the stored potatoes; (3) how the storages are managed, and (4) problems and difficulties that storage managers have been experiencing.

A total of over 500 surveys were sent out, 87 surveys were completed and returned. The survey data included 161 storage buildings which represents about one third of the total storage capacity in Washington.

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RESULTS

Storage Ownership

The majority of the respondents (82.9%) are owners who operate their own storages, 2.6% are owners only and 14.5% are managers only.

Size of Storage Enterprise

In this report the term "enterprise" is the number of storage buildings under the same management. The smallest enterprise consists of one and the largest consists of 28 storage buildings.

Two thirds of the enterprises are small (controlling one or two storages), the largest enterprises with 5 or more buildings, comprise about half of the storage buildings. Figure 1 illustrates the enterprise size distribution.

Type of Construction and Age of Buildings

The most prevalent construction type is wood frame construction (47%). Steel construction makes up 41% of the structures and 12% are concrete buildings. The average age of wood buildings is 14.7 years. For steel buildings it is only 9.4 years.

Insulation

The most popular insulation material used is sprayed-on polyurethane which is used in 59% of all buildings. Glass fiber is used in 24% of buildings. Rigid board insulation is used in 15% of the buildings. This includes polystyrene (9%), polyurethane (3%) and polyisocyanurate (3%). Rockwool and sawdust uses are insignificant.

Average R-value of insultation is R-25.1 in ceilings and R-22.5 in the walls. R-value ranged from less than R-10 to over R-40, with 32% being in the R-11 to R-20 range and 47% being in the R-21 to R-30 range.

Vapor Barriers

An effective continuous vapor barrier on the inside surface is essential to prevent moisture movement into the insulation and wooden structural members. In general the opinion has been that sprayed-on polyurethane insulation has enough resistance to moisture penetration to be a vapor barrier. Although polyurethane offers resistance toward water vapors, it is not a vapor barrier. Its permeability to moisture is highly variable.

Fifty-nine percent of the buildings reported have bare sprayed-on polyurethane insulation. The permeability for 4 inches of newly applied polyurethane will range from 0.1 to 0.4 perms*, depending on density and quality of application. With age the permeability increases significantly. The American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE) recommends a perm rating of 0.1 perm or less for cold storage rooms. For potato storages a perm rating of no more than 0.15 perm is advisable.

Fiberglass insulation is generally installed with polyethylene vapor barriers which, when installed properly, should not let vapors through. However, the survey indicates that 62% of the buildings have problems with moisture in fiberglass insulation. This indicates that many vapor barriers had been improperly installed or were broken with equipment and storage use.

The use of rigid board insulation has increased rapidly during the past few years. These boards are generally covered with foil-type vapor barriers on both sides. Very few owners have indicated problems with moisture accumulation in this type of insulation. This is expected since building with rigid board insulation are newer, and it generally takes several years for a significant amount of moisture to accumulate in insulation boards with foil on both sides. Potential problems with this type of insulation are inadequate sealing of joints, loosening of the tape, and breaking the foil-type vapor barrier with equipment. When this occurs moisture migration into the insultation can be expected.

STORAGE ENVIRONMENT

The storage environment consists of maintaining the proper temperature and relative humidity levels. Very high relative humidity levels are needed to minimize shrinkage losses and to maintain tuber quality.

Relative humidity levels measured in the plenum are shown in Figure 2. The average RH during suberization is 94.8%, ranging from 65% to 100%. During long term storage the average humidity level is reduced to 91.1%, with a range of 60 to 100%. Only 5% of the storage operators maintain an RH below 86% during suberization, and only 10% maintain an RH below 86% during long-term storage.

Major factors in maintaining a desired storage environment are the ventilation system, air conditioning (humidification and refrigeration), control of the equipment and system operation practices. The following system and practices were reported:

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* Perm = grains of water/hr-ft^2-in. Hg vapor pressure. One pound equals 7,000 grains.

Humidification Systems	Percent of storages
Centrifugal humidifier	39 %
Air washers	25 %
Nozzles in plenum	25 %
Evaporative type cooling system	1 %
None	10 %

Refrigeration System	Percent of storages
Air washer with chiller	11 %
Evaporator coils	13 %
None	76 %

Temperature Probes	Percent of storages
Outside, dry bulb temp	77 %
Outside, wet bulb temp	44 %
Plenum temperature	80 %
Pile temperature	44 %
Return air temperature	63 %

Ventilation fan operation

As much as possible during suberization	90 % of storages
Minimum hours/day during suberization	17.2 Hrs/day
Minimum hours/day during long term storage	16.5 Hrs/day

PROBLEMS

The desired high humidity environment for the stored crop is a harsh environment for the structure containing the crop and leads to deterioration of the building. Moisture from condensation and other sources penetrates and accumulates in insulation and wooden members and causes rot in wood and rusting of steel. Other problems include breakdown of tubers, and excessive maintenance requirements on buildings and equipment.

The questionnaire contained questions concerning problems with storages. A summary of the answers is shown in Figure 3. Each horizontal bar is made of two sections. The left section shows the extent of each problem (percentage of storages reporting a specific problem) and the right section of the bar illustrates the severity of the problem. A severity rating of 1 is a slight problem, 2 a moderate problem and 3 a severe problem as judged by the owner. The average severity shown is a weighted average of all the storages, which takes into account the rating and the number of storages for each rating.

Figure 3 contains 4 sections: (1) structural deterioration, (2) moisture and condensation problems, (3) pressure bruising and tuber breakdown, and (4) system maintenance problems.

Structural Deterioration

Major structural deterioration problems are rotting of wooden structural members and rusting of siding and roofing. Over half of the reported structures have deterioration problems. Average severity level is slightly below "moderate"; although 11% of the structures were reported to have severe deterioration. Almost half of the storages have rot in wooden members, with a moderate severity level. Rusting of steel is less prevalent and the problem is less severe.

Condensation and Other Moisture Problems

Condensation is the most prevalent problem in potato storages. Almost 3 out of 4 buildings are having a problem with condensation on the ceilings. Condensation on walls appears to be less of a problem, however, it may be hidden by the pile. Dripping condensation onto the pile was also stated as a problem. Over half of the storages reported problems with moisture in insulation and structural members. Condensation is the major source of this moisture.

Excessive moisture in the ducts is considered only a "slight" problem by the operators. If this moisture moves into the pile it may contribute to a breakdown of tubers around the ducts, which is occurring in 32% of the storages. In general, moisture problems are considered less severe (between slight and moderate) than are structural deterioration problems.

Tuber Problems

Decaying of tubers in the pile was reported in almost half of the storages, however the severity is considered to be only slight by most operators.

Pressure bruising occurs in over one-half of the storages. Forty-three percent reported a slight problem and 12% are experiencing moderate pressure bruising.

Pile depth did not seem to be a major factor in pressure bruising as illustrated in Figure 4. Slight and moderate bruising occurs in all depth ranges (8-12 ft), (13-17 ft), and (18-22 ft). However, there is a trend of decreasing pressure bruising with increased humidity levels.

Maintenance

One-third to one-half of the storages were reported to have excessive maintenance problems. Excessive major equipment maintenance is needed for humidification, refrigeration and automatic control systems. Major structural maintenance is required for structural members, insulation and external covering.

COMMENTS

Major problems were reported by the growers in the comments section of the survey. Listed in order of decreasing severity, they are:

1. Dry-rot in wooden members.
2. Deterioration of steel in buildings with sprayed-on polyurethane insulation.
3. Too much moisture in plenum.
4. Moisture in insulation.
5. Condensation.
6. Pressure bruising.

Information requested in the comments section included:

1. How to prevent moisture absorption by wood.
2. How to repair and update older structures.
3. How much humidity needed in plenum (ventilation air).
4. How many hours per day should the ventilation system be operated.
5. Performance comparison of different humidification systems.
6. Long term cost comparison of different types of storage construction.

SUMMARY

1. The most severe reported potato storage problem in Washington is structural deterioration which includes rot of wooden structural members and rusting of siding and roofing.
2. Over 80% of rusting of siding and roofing is in buildings that have sprayed-on polyurethane insulation.
3. The most frequently occurring problem is condensation on ceilings and walls and resulting moisture migration into building components (insulation and wooden members), and dripping onto pile. These problems were considered less severe than deterioration of the structure.
4. Information needs focus on solving major storage and storage management problems which include (1) prevention of structural deterioration, (2) repair of storages and (3) operation of ventilation system.

REFERENCES

ASHRAE Handbook of Fundamentals, 1986. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., New York.

Waelti, Henry, 1986. Insultation, condensation and wood decay in potato storage buildings. Proceedings, 25th Annual Washington State Potato Conference and Trade Fair.

Waelti, Henry, 1987. Insulation and Vapor barriers in potato storage buildings. PNW Extension Publication 295, W.S.U., Pullman, Wa.

Figure 1. Enterprise size distribution and the percentage of storage buildings represented by each enterprise size.

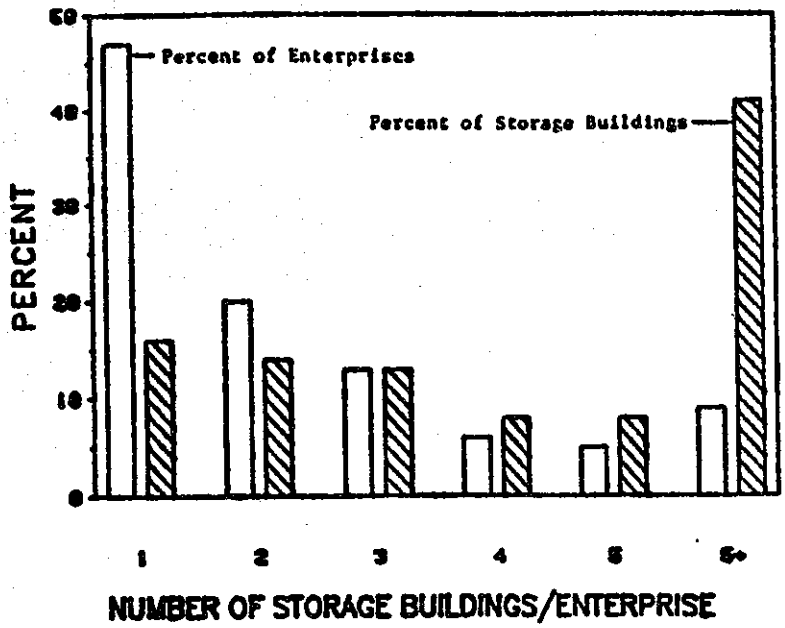

Figure 2. Relative humidity levels in the plenum during suberization and after suberization. The average humidity level during suberization is 94.8% and after suberization, 91.1%.

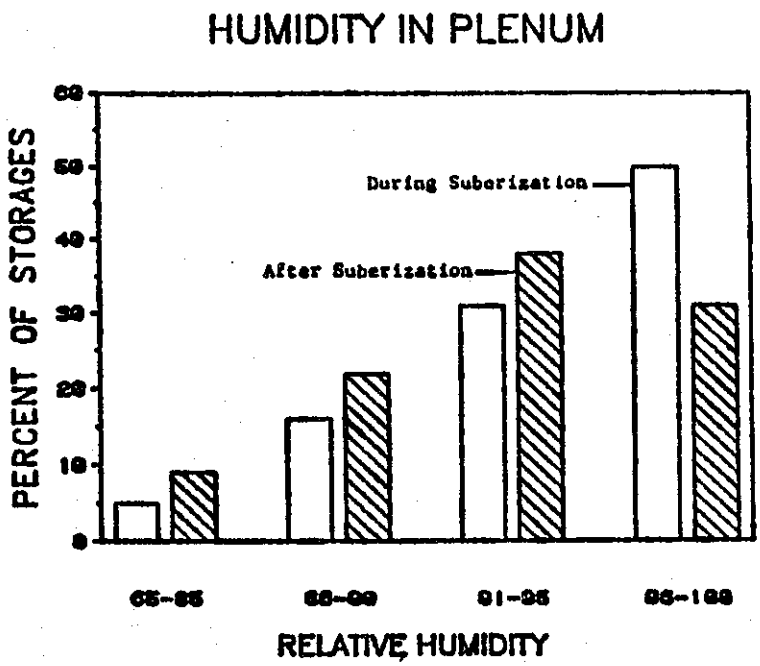

Figure 3. Summary of reported problems. The left side of the graph shows the percentage of reported storages having problems and the right side illustrates the perceived severity level (1=slight, 2=moderate and 3=severe problem).

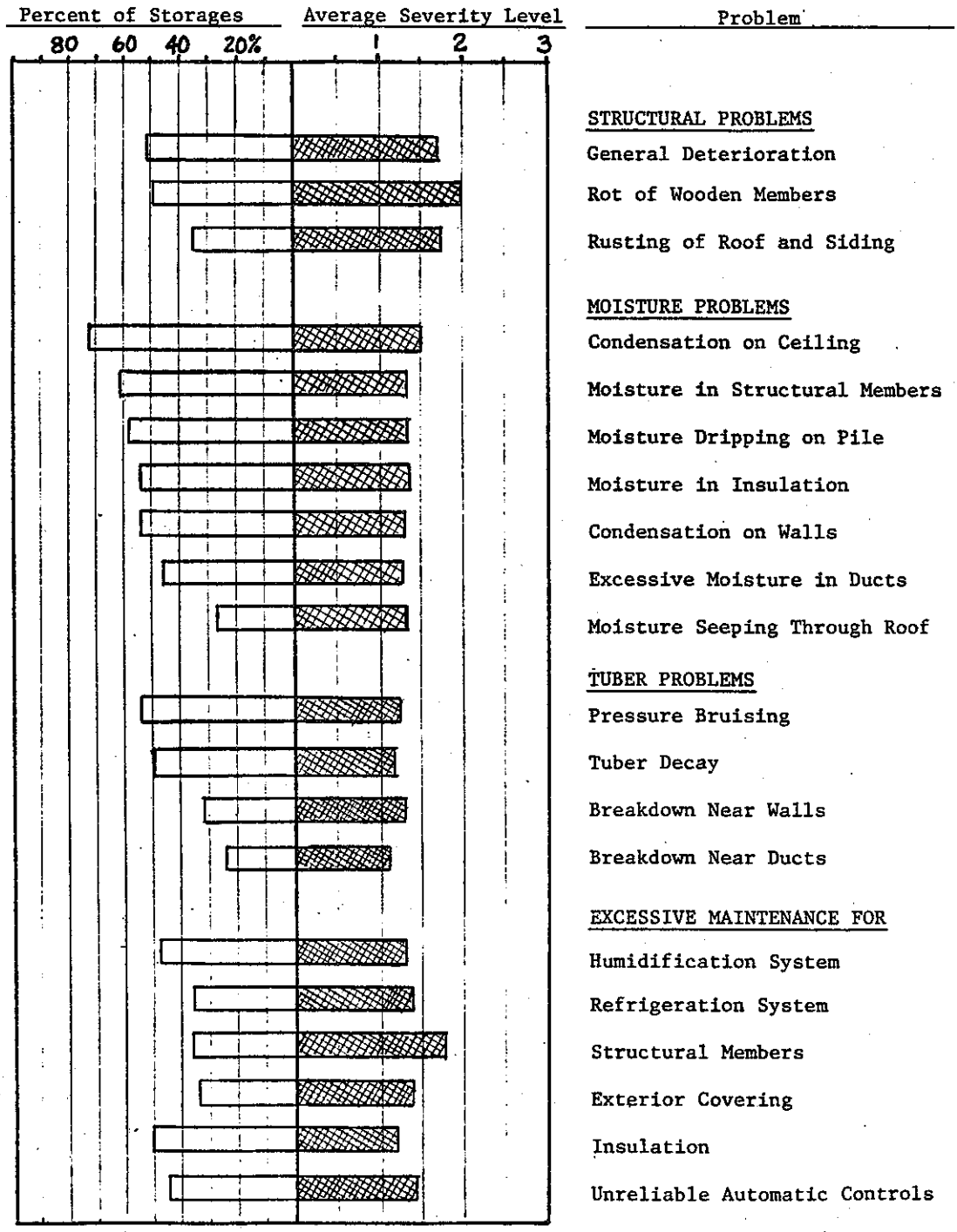

Figure 4. Pressure bruising for three different pile depth levels.