NON-PROPRIETARY
SAFTEY ANALYSIS REPORT
FOR THE
NUPAC
N-55 PACKAGING

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1.0 GENERAL INFORMATION

1.1 Introduction

The NuPac N-55 Packaging, Model No. : N-55, has been developed by Nuclear Packaging, Inc., as a safe means of transporting radioactive material including fissile material in the form of dry solids contained within a containment vessel defined as a 55 gallon drum shown in appendix 1.3.2. Dispersible forms such as liquids, powders, and slurries are excluded.

The N-55 overpack surrounds and protects the 55 gallon drum from the normal conditions of transport and the hypothetical accident conditions set forth in 10 CFR 71. No shielding is provided by the overpack.

Authorization is sought for a Type B(U) shipment by cargo vessel, motor vehicle, and rail.

1.2 Package Description

1.2.1 Packaging

The NuPac N-55 Packaging is a cylindrical, surrounding overpack, 48.0 inches tall, 32.0 inches in diameter, with a gross weight, including payload, not to exceed 750 pounds. The cavity is designed to carry a 55 gallon drum, as shown in appendix 1.3.2, the cavity height and diameter are 35.5 inches and 24.0 inches, respectively. These dimensions are provided in the general arrangement drawing found in Section 1.3.1.

The outer shell of the overpack is fabricated of galvanized 20 (or 18) gauge ductile low carbon steel. The inner shell is molded from a high impact fiberglass material. This provides a tough, high strength liner able to take abrasive handling and corrosive materials as well as the normal and hypothetical accident conditions. The volume between the inner and outer shells is filled with a shock and thermal insulating material consisting of rigid polyurethane foam having a density of approximately three pounds per cubic foot. The liquid foam is poured into the cavity between the two shells and

allowed to expand, completely filling the void. There it bounds to the shells thereby creating a unitized construction for the packaging.

Once assembled, the overpack takes the shape of a vertical, right angle cylinder with a separation plane located 18.0 inches from the top. In use, the lower unit comprises the body or base of the container while the upper unit serves as the lid. The stepped joint between the two halves is sealed with a neoprene gasket.

Closure of the lid and body is maintained via four high capacity 'over-center' locking latch devices, each with a secondary lock to resist release during normal and hypothetical accident conditions.

The N-55 overpack is not intended to be the containment vessel, but rather provides a prime function of reducing the severity of the hypothetical accident conditions thereby assuring there will be no loss of contents from the 55 gallon drum.

The containment vessel is a gasketed, 55 gallon drum, as shown in appendix 1.3.2. This drum meets the requirements of the currently obsolete DOT Specification 17H or 17C as delineated in the 1990 49 CFR 178.118 or 49 CFR 178.115, respectively. A testing program was designed to qualify this container as meeting the normal conditions of transport. Because the physical form of the package contents excludes dispersible forms such as liquids, powders, and slurries, and because actual hypothetical accident level test conditions has shown only minimal deformation to the drum with no loss of contents, the leakage tests to verify containment under hypothetical accident conditions are not required per current ANSI N14.5 standards.

Four lifting devices are provided on the N-55 Packaging as shown in the general arrangement drawing in Section 1.3. A detailed analysis of their structural integrity is provided in Section 2.5.1. There are no tiedown devices which are a structural part of the package.

There are no special methods utilized for the dissipation of heat. The maximum internal thermal loading is 3.0 thermal watts. A detailed thermal analysis is provided in Section 3.0.

There are no neutron absorbers, receptacles, sampling ports, pressure relief devices or coolants, and no shielding is provided by the N-55 Packaging.

Appendix 1.3

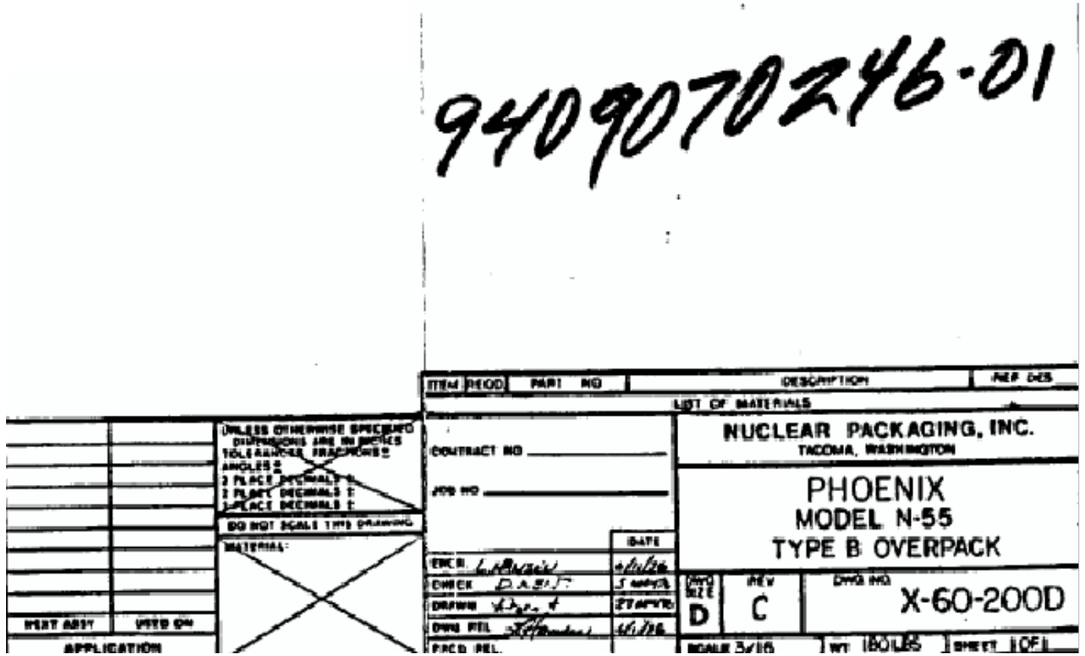
Appendix 1.3.1

General arrangement drawing of the N-55 Packaging, X-60-200D-SNP, Rev. J.
General arrangement drawing of the N-55 Packaging, X-60-200D, Rev. C.

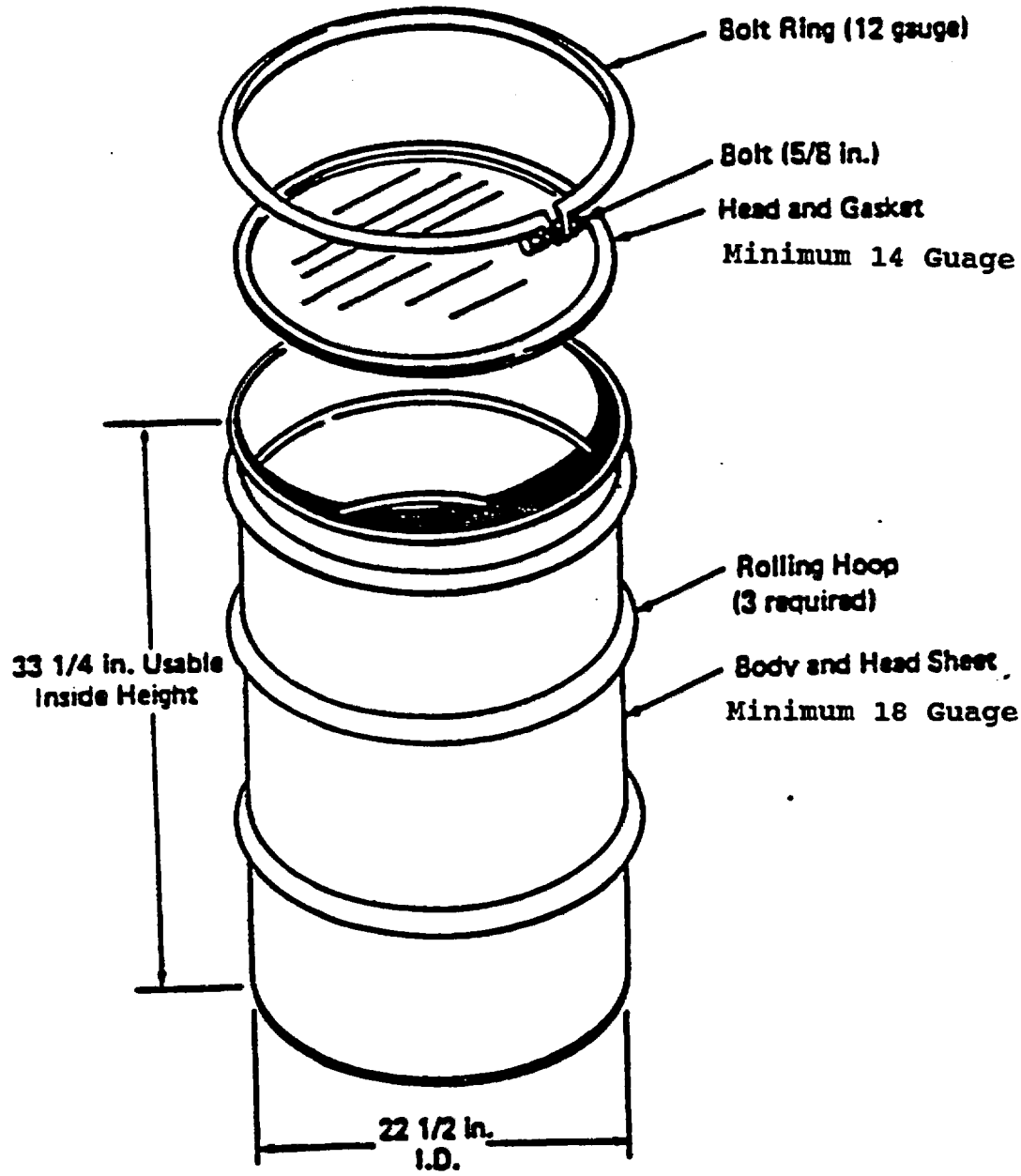
Appendix 1.3.2

Requirements for 55 gallon drum to be used with this package.

FIGURE WITHHELD UNDER 10 CFR 2.390



Steel Drum (55 gallon)
(17H or 17C)



Pressure Tested to 15 psig.

A detailed thermal analysis can be found in Section 3.4 wherein the package was exposed to direct sunlight and 100°F still, ambient air. The steady state heat transfer analysis conservatively assumed a 24 hour day maximum solar heat load. A summary of the temperatures at key locations is provided below:

Location	Maximum Temperature (°F)
Outer Shell	153.8
Inner Shell	161.5
55 gal drum	161.9
Payload	161.9

The internal pressure within the 55 gallon drum may be found utilizing the ideal gas law from thermodynamics. Conservatively assume a static loading temperature of -40°F, and a steady state payload temperature of 161.9°F which totals a 201.9°F change in temperature. Assuming air, the change in internal pressure may be found to be:

$$P_1V_1/T_1 = P_2V_2/T_2$$

Assuming a constant volume, the equation reduces to:

$$P_1/P_2 = T_1/T_2$$

$$P_2 = (14.7 \text{ psia})[(201.9 + 459.69)/(-40 + 459.69)]$$

$$= 23.2 \text{ psia} = 8.5 \text{ psig}$$

Since the pressure due to the rise in temperature within the drum is small (at a minimum, the specified drum is pressure tested to 15 psig), stresses due to thermal effects may be considered negligible.

2.6.2 Cold

The effects of a steady-state temperature of -40°F are considered to be negligible due to the materials of construction. All ferric steel components (i.e., the outer shell, 55

gallon drum, etc.) are thin sections (less than 3/16 inch) and constitute no concern from a brittle fracture standpoint (per Section 5.2.3 of NUREG/CR-1815, Recommendations For Protecting Against Failure By Brittle Fracture in Ferritic Steel Shipping Containers Up To Four Inches Thick, for Category II fracture toughness). All other materials of construction are relatively insensitive to the reduced temperature, including the effects of brittle fracture. The package contains no fluids which could freeze and expand such as water.

2.6.3 Reduced External Pressure

As discussed in Section 1.2.1, the overpack is not intended to resist either internal or external pressures. A weather seal located along the package lid/body interface is designed to minimize the entrance of external environmental elements such as rain, dust, etc. In addition, the overpack is designed to vent internal pressure.

The steel, 55 gallon containers are required meet the drum requirements as shown in appendix 1.3.2. As such, these drums are required to be hydrostatically tested to 15 psig internal pressure. Therefore, it may be concluded that the system will adequately resist a reduced external pressure of 3.5 psia (11.2 psig internal pressure) per the requirements of 10 CFR 71.71(c)(3).

package. Two modifications to the geometry were implemented and three additional 30 foot drop tests were then performed using a newly fabricated N-55.

For the first test series, a full size N-55 overpack was fabricated and the weight was measured to be 180 pounds. A 55 gallon drum, was filled with sand to a weight of 570 pounds, thereby assuring a gross test weight of 750 pounds. The drum's lid was installed and pressure tested with air to 10 psig. No leaks were noted. The drum was installed into the N-55 overpack body (lower half), followed by the N-55 overpack lid. The four toggle-latches were secured for testing. Below is a summary of the drop orientations and corresponding results. Drop test photos may be found in Appendix 2.10.2.

2.7.1.1 Drop 1 - Lid-End Corner Drop from 30 Feet

The N-55 Packaging was raised to a height of 30 feet above the test pad (see photo P-1, Appendix 2.10.2) and released with an orientation that would provide a corner impact directly over the drum's bolt ring. The angle of impact was set to the c.g. (center of gravity) directly over the impacted corner, i.e., approximately 56.3° from horizontal.

Upon impact, the N-55 overpack crushed to a depth of approximately 8.0 inches as shown in photo P-2. All latches remained firmly intact with no indication of yielding.

2.7.1.2 Drop 2 - Bottom-End Corner Drop from 30 Feet

Following the first test, the N-55 Packaging was reconnected to the quick-release mechanism, positioned so as to impact upon the corner diagonally opposite that impacted in the first test, raised to a height of 30 feet, and released. Upon impact, the N-55 overpack crushed to a depth of approximately 4.5 inches as shown in photos P-2 and P-3. As before, all latches remained firmly intact with no evidence of yielding.

2.7.1.3 Drop 3 - Side Drop from 30 Feet

The N-55 Packaging was again reconnected to the quick-release mechanism, raised to a height of 30 feet, and released in a side impact orientation directly over one of the four latches.

3.0 THERMAL EVALUATION

This section identifies and describes the principal thermal engineering design aspects of the N-55 Packaging important to safety and compliance with the performance requirements of 10 CFR 71.

3.1 Discussion

The N-55 Packaging is designed with a totally passive thermal system. The principal physical characteristics of this thermal system consist of a fully enclosing overpack surrounding a 55 gallon drum. The overpack is fabricated of 20 gauge (0.0359 inch thick) galvanized sheet steel outer shell, a 0.125 inch thick fiberglass inner shell, and approximately three pound per cubic foot closed-cell polyurethane foam in between. The payload consists of a 55 gallon drum with three forms of contents as described in Section 1.2.3.

Three heat transfer analyses were run for each of the three classifications of payload utilizing the computer thermal network analyzer program THAN:

(1) A normal condition steady-state analysis at an ambient temperature of 100°F with insulation,

(2) An accident condition steady-state analysis at an ambient temperature of 100°F without insulation, and

(3)An accident condition transient analysis at an ambient temperature of 1,475°F for thirty minutes followed by exposure to 100°F ambient air with sufficient time for temperatures throughout the package to maximize.

As discussed in Section 1.2.3, the N-55 packaging is analyzed for 3.0 thermal watts. Maximum temperatures at various locations within the N-55 Packaging are presented in Table 3.1-1. Details of the thermal analyses are presented in Sections 3.4 and 3.5.

Assuming a constant volume, the equation reduces to:

$$P_1/P_2 = T_1/T_2$$
$$P_2 = (14.7 \text{ psia})[(201.9 + 459.69)/(-40 + 459.69)]$$
$$= 23.2 \text{ psia} = 8.5 \text{ psig}$$

3.4.5 Maximum Thermal Stresses

Since the pressure due to the rise in temperature within the drum is small (the drum is pressure tested to 15 psig), stresses due to thermal effects may be considered negligible.

3.4.6 Evaluation of Package Performance for Normal Conditions of Transport

It can be readily seen by the calculations presented above that the N-55 Packaging will meet all the thermal requirements of the normal conditions of transport.

3.5 Hypothetical Accident Thermal Evaluation

This section presents the thermal analyses of the N-55 Packaging for the hypothetical accident fire condition specified in 10 CFR 71.73(c)(3). The initial temperature distribution in the package prior to the fire is taken as that corresponding to the 100°F steady state condition of Section 3.4, without insulation, in accordance with 10 CFR 71.73(b). To determine the effect of the fire, the package is exposed to a 1,475°F fire for a period of thirty minutes at which time the thermal boundary is returned to a 100°F ambient air condition as specified in 10 CFR 71.73(c)(3). The transient analysis is continued for a time sufficient to determine the maximum values for all temperatures within the package. Those nodes not achieving a maximum temperature within a period of ten hours following the end of the fire have been so noted.

4.0 CONTAINMENT

The containment boundary of the NuPac N-55 packaging consists of a 55-gallon drum, as shown in appendix 1.3.2.

The contents are limited, per Section 1.2.3, to dry, solid forms of radioactive material. Hence, the 55 gallon drums are necessary only to serve as a means of confinement for the non-dispersible radioactive material. Actual leak testing of the 55 gallon drums is not necessary to meet the requirements of 10 CFR 71.

As demonstrated by full scale testing and as discussed in Sections 2.6 and 2.7, the N-55 overpack adequately protects the various containment vessels. The presence of the overpack ensures that containment vessel damage will be limited and that a release of radioactive material will not occur under the specified normal or accident conditions.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 Acceptance Tests

The N-55 Packaging shall be inspected and released for use by a responsible employee prior to loading. The following items will be included in such inspections:

1. The entire package, both inside and out, shall be visually inspected and assured that it has not been significantly damaged (no cracks, punctures, holes, nor broken welds) per the requirement of 10 CFR 71.85(a).
2. Toggle clamps and gaskets must be present and free of defects.
3. The exterior nameplate must be in place and legible, bearing the packaging identification number, model number, gross weight, and certificate of compliance number per the requirement of 10 CFR 71.85(c).
4. Follow all company operating procedures and complete all necessary records for the handling and operation of the N-55 Packaging.

NOTE: The requirement of 10 CFR 71.85(b) for pressure testing the containment system to a level 50% higher than the normal operating pressure is unnecessary. From Section 2.6.1, 150% of the 8.5 psig normal operating pressure is still below the 15 psig test pressure the 55 gallon drum.

8.2 Maintenance Program

A good sound industrial maintenance program should be followed to assure the integrity of the N-55 packaging. Components such as gaskets, toggle clamps, and components necessary for the safe and easy operation of the packaging should be given regular inspection and repaired or replaced as necessary.