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LIMITATIONS FOR EXISTING STORAGE TANKS FOR
RADIOACTIVE WASTES FROM SEPARATIONS PLANTS

by

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LIMITATIONS FOR EXISTING STORAGE TANKS FOR
RADIOACTIVE WASTES FROM SEPARATIONS PLANTSI. INTRODUCTION

Continued process improvements in the separations plants provide an incentive for economies in waste storage costs by utilizing existing facilities to their maximum capability consistent with the radiological hazards involved. The major improvements have reduced waste volumes resulting in increased fission product concentration and energy potential. Analyses have been made to determine the effect of this change on the integrity of the existing structures. 1, 2, 3, 10

II. PURPOSE

The purpose of this report is to define the physical limitations of the existing structures, as a guide for preparing process and operating criteria for the existing tank farms to assure continued integrity of the tanks.

III. SUMMARY AND CONCLUSIONS

The eleven existing tank farms have been divided into four groups characteristic to their structural features and to their intended use. These groups consist of: (1) Purex tank farm 241-A; (2) Redox tank farm 241-SX, both for self-boiling wastes; (3) Tank farms 241-S, BY, TX, TY consisting of 750,000 gallon capacity tanks; and (4) Tank farms 241-T, U, B, C, BX consisting of 530,000 gallon capacity tanks, these two groups being for non-boiling wastes.

Figures 1 through 4, attached, provide a "safe-load" curve for each of the four groups of tanks based on current technology. These curves are a function of maximum allowable working stresses, specific gravity, temperature differential across the structure, instantaneous loading factor for vapor pressure surges, and the assumption that the structural elements have undergone no deleterious phenomena due to age or usage.

The recommendations of the Portland Cement Association and the American Concrete Institute were followed in establishing the maximum allowable working stresses for this study. Basically, the allowable steel stress in ring tension was 16,000 pounds per square inch. Allowable steel stress for ring tension is often kept as low as 12,000 or even 10,000 pounds per square inch, although this lower ring tension stress would tend to increase the bond stress. A study of the high-level radioactive storage tanks at the Savannah River Plant revealed a maximum ring tension of about 12,000 pounds per square inch. For HAP0's storage tanks an allowable stress in ring tension of 16,000 pounds per square inch was used to provide maximum safe storage volumes in existing tanks recognizing that the steel liner would provide the primary leakage barrier.

A liquid specific gravity of 1.37 was used for wastes to be stored in 241-A type tanks and 1.68 was used for wastes to be stored in 241-SX type tanks. It was understood that these are the maximum respective specific gravities which could be attained under controlled operations of self-boiling wastes in these tanks.

The maximum liquid specific gravity of 1.9 was used for the non-boiling wastes. It was understood that this would be the maximum specific gravity which could be achieved from evaporation by localized heating and still retain a transferrable liquid in the storage tank.

A temperature gradient of 23° F per foot of thickness across the structural components of the tank was used to estimate the thermal stresses. Extensive studies have been conducted to define the transient heat flow through the walls of the waste storage tanks. 1, 2, 15 The tank contents should be heated slowly in accordance with the recommended rate of temperature increase provided in Fig. 6, attached, in order not to exceed this temperature gradient across the wall.

When a pressure surge is experienced in a self-boiling tank the resulting vapor pressure is equated to an equivalent static load for stress analysis by an instantaneous loading factor. The rate of pressure rise and the period of vibration of the structure define this instantaneous loading factor. An instantaneous loading factor of "one" was used in this study to provide maximum storage volume in the self-boiling tanks. Vapor pressures within this storage space have been recorded in the range of 15 to 30 per cent of the accompanying hydrostatic load of the stored waste in the presence of a large bleed-off space. The recommended safe liquid depths in Figs. 1 and 2 were based on an anticipated vapor pressure of this magnitude.

The instability of the bottoms of the 113-SX and the 104-U tank is postulated to have been caused by vaporization of moisture present in the two-inch layer of grout trapped between the steel liner and the asphaltic membrane. When this vaporization pressure, caused by elevated temperatures, beneath the liner exceeds the hydrostatic load on the liner, there is a possibility for the liner to become unstable and to deform upward developing a reversed dish gas dome when the moisture vaporizes. This unstable condition could be minimized by providing a hydrostatic load on the liner in excess of this vaporization pressure. The maximum recommended hydrostatic loads for 241-A and Redox 241-SX tanks are 14 psig and 12.5 psig respectively. These pressures would permit a temperature of about 245° F in the grout. It is known that a few tanks are currently exceeding this temperature without excessive displacement of the bottom while other tank bottoms may have undergone some displacement without being detected. Fig. 5, attached, has been developed to provide a safe-operating curve for the self-boiling tanks based on this theory. Fig. 5 is explained in the discussion of this report.

IV. RECOMMENDATIONS

The following recommendations are presented to provide safe loading combinations for existing radioactive wastes storage tanks based on current technology.

1. The safe load curves presented in Figs. 1 through 4 should be used to determine the maximum safe liquid level consistent with anticipated vapor pressures and specific gravities. For example:

<u>Fig. No.</u>	<u>Type Tank</u>	<u>Type Waste</u>	<u>Sp.Gr.</u>	<u>Vapor Pressure</u>	<u>Liquid Level</u>
Fig. 1	241-A	Self-boiling	1.37	3.0 psig	21.5 ft.
Fig. 2	241-SX	Self-boiling	1.68	2.5 psig	16 ft.
Fig. 3	S,BY,TX,TY	Non-boiling	1.8	0 psig	15 ft.
Fig. 4	T,U,B,C,BX	Non-boiling	1.8	0 psig	14 ft.

2. The tank bottom temperatures should not exceed the corresponding equivalent hydrostatic load required to hold down the tank bottom. The "safe-curve" is plotted in Fig. 5, attached. For example, a tank bottom temperature of 230° F would require an equivalent hydrostatic load of 6 psig. For a liquid specific gravity of 1.37, this would result in a liquid depth of 10 feet.

After the bottom temperatures have been maintained at approximately 230° F ($\pm 10^\circ$) for a period of eight weeks, a gradual increase in these temperatures could be permitted to a maximum of 300° F. See Fig. 6, attached. Behavior of the tank bottom should be observed during this period. If displacement of the bottom of more than a few inches is detected, the temperatures should be lowered to the vaporization temperature in accordance with Fig. 5.

3. The rate of increase of liquid waste temperature should not exceed the curves presented in Fig. 6, in order not to exceed the maximum temperature gradient across the structural components of the tanks. The recommended uniform rate of temperature increase is 2° F per day. The maximum incremental temperature increase is 40° F which could occur instantaneously. It is recommended that a 50,000-gallon liquid heel at ambient ground temperature be placed in a tank before the addition of higher temperature wastes.

V. DISCUSSIONA. Determination of Loading Conditions

It is desired to achieve maximum utilization of the existing storage tanks to contain high-level, self-boiling wastes. At Purex, this can

best be done by having the 241-A type tank provide safe storage through the boiling cycle of the stored fission products. At Redox, this can best be done by having the non-boiling wastes in the 241-SX tanks transferred to self-boiling tanks and then re-use the reclaimed SX tanks for fresh boiling wastes. Other non-boiling wastes in the older tank farms could be reduced in volume by localized heating within the tank to evaporate the excess water.

Technological advances in both the Redox and Purex processes have resulted in waste volume reductions with corresponding increases in fission product concentrations and heat generation per unit of volume. In order to realize the potential savings from these volume reductions, it is desirable to store self-boiling wastes in the 241-SX and 241-A tanks for extended periods of ten years or longer. The more concentrated fission products produce a faster heat-up of the solution and have a potential for more self-concentration of the solution.

The 241-A and 241-SX waste storage tanks, which are the two most recent of the four tank designs, were not structurally designed for the potential physical properties of current self-boiling wastes from the Purex and Redox separations processes. It is therefore mandatory to specify the combinations of permissible loadings induced by these wastes to achieve maximum waste storage economies under controlled and safe operating conditions. The inability to observe the behavior and to make structural repairs on these structures either internally or externally during their life time necessitate the use of recognized design codes to define the safe operating loads. The severity of the hazards and the possibility of delayed control also predicates conservatism in applying the design codes to these structures. Stress analyses and design codes, as recommended by the Portland Cement Association ⁴ and the American Concrete Institute ¹² were followed in establishing the safe-load curves in Figs. 1 through 4 inclusive.

Today, the potentially high temperatures and the potentially rapid rate of temperature change associated with storing concentrated fission products in a liquid slurry could impose the most severe loading conditions for existing structures containing self-boiling wastes. ¹³ Control has been maintained to such a degree that only a fraction of these potentials have ever been experienced in existing 241-A and 241-SX type storage tanks.

An extensive literary review, heat transfer studies, and related operating capabilities of existing facilities predicate the temperatures to be uniform and steady and the maximum waste temperature to be controlled to less than 300° F and that the rate of temperature rise be in accordance with Fig. 6, attached. Exposure of these large monolithic, composite structures to elevated temperature induces complexities in the stress analysis, which are dependent on the validity of the assumptions. It is prudent to keep the temperatures as low as possible in these structures while permitting self-concentration.

Primarily, a temperature change induces three phenomenas on these large structures. The first is the effect on the physical properties of the material; second is the effect on the growth of the material accompanied by a change in the temperature; and third is fatigue failure caused by fluctuating temperatures.

Investigations on the physical properties of portland cement concrete and grout when exposed to elevated temperatures have been performed in recent years for use in design of thick concrete shields for reactors.^{8,9} The results of these studies apply significantly to the thick structural concrete walls of the 241-A and 241-SX type tanks. At temperatures above 200° F, some of the water of hydration is removed from the hardened mix in addition to the free or evaporable water. Loss in strength follows any loss in hydrated water from the hardened cement mix. Upon loss of water, concrete also tends to shrink, and if restrained, cracking may occur.⁸ At temperatures in the range of 500° F to 600° F the modulus of elasticity of the concrete decreases about 20 percent and the bond strength decreases approximately 30 per cent under controlled laboratory tests.

The volume change of the structure due to thermal change becomes a complex problem because of the non-uniform temperature gradients which are developed within the structure. For instance, during tank heat-up, the interior surface will be at a higher temperature than the exterior surface and when the tank has sludge layers at elevated temperatures the tank bottom and lower portion of the cylindrical walls will be at a higher temperature than the upper portion of the wall and the concrete dome. These differential temperatures induce restrained strains which can be correlated to equivalent stresses in the structure to define critical temperatures and structural sections. A discussion of stress analysis based upon this phenomena is presented in references 4 and 8 of this report. From these discussions it can be calculated that the thick concrete walls of an existing tank storing self-boiling wastes have cracked by the time the wastes have reached a boiling temperature. The severity of these cracks in the concrete is difficult to define and their magnitude is dependent upon the parameters involved during the heat-up period. The recommended uniform rate of temperature rise of 2° F per day will aid in minimizing the cracking of the concrete during heat-up and maintain a structurally sound container without unduely restricting the operating procedures.

The loss in strength in laboratory specimens of concrete subjected to wide fluctuations in temperature has been observed to be two to three times as great as for constant exposure to high temperature, depending upon the severity of the thermal cycle. Unfortunately, there is very little information published on the thermal cycling of concrete.⁸ It is therefore recommended that the waste temperatures be controlled between boiling and 300° F. Rates of temperature change should also be as slow as possible.

Self-concentration can be achieved at temperatures below 300° F in existing tanks. If economic justification can be established to exceed this temperature then an extensive structural review should be made of these structures by a qualified consultant based on the justified maximum temperatures. It is questionable that a more vigorous solution could establish higher allowable temperatures in the existing storage tanks without visual or physical inspection of the concrete to establish its present condition.

Recent experience in the instability of the bottom of tank 113-SX, which caused an inverted dish with a four-foot vertical displacement of the tank bottom, amplifies the justification for control of temperatures when storing self-boiling wastes. Whether or not the instability of the bottom was caused by vapor, by liquid, by thermal expansion, or by a combination of these, is more or less of academic interest.¹⁰ The important consideration is that this magnitude of instability should be prevented in existing tanks because of the inability to establish the integrity of the tank.

It is recognized that the hydrostatic load on the tank bottom resists the vaporization pressures caused by the release of moisture upon heating. Moisture is available in the 2-inch layer of portland cement grout between the steel liner and the 3-ply asphaltic waterproofing membrane. The quantity of water required for bulging the bottom of tank 113-SX has been estimated at five cubic feet or less.¹¹ Laboratory tests performed by the Corps of Engineers⁹ reveal that portland cement grout could lose approximately eight percent of its total weight upon heating from room temperature to 230° F. Approximately three percent of its total weight could be lost during the curing period. This would leave about five percent available for loss during heating which would amount to about 80 cubic feet of water available for vaporization. Recent vaporization tests on laboratory samples indicated that the release of moisture upon heating could cause elevated vapor pressures.¹⁴

Coincidentally, the vaporization pressure (20.7 to 29.8 psia) for the saturation temperature (230° to 250° F) at which the storage tanks are most commonly operated is approximately equal to the hydrostatic load on the tank bottom. This pressure is also equal to the recommended hydrostatic load on the wall of the structure. An increase in the temperature of the stored waste would also increase the saturation temperature thus increasing the vaporization pressure. For example, a stored waste at 280° F would have a potential vaporization pressure of 34.5 psig, (equivalent to a liquid depth of 48 feet at 1.67 sp gr). Therefore, sufficient hydrostatic loading cannot be obtained to hold the tank bottom down at temperatures above 250° F. Heating the tanks above 250° F should be delayed as long as possible to permit depletion of the moisture from the grout and frequent monitoring should be made of the tank bottom to determine its behavior.

The elliptical dome of the 241-A and 241-SX type storage tanks was designed for a very heavy external earth loading which was required for shielding. The reinforcing steel in the dome, except for the hoop steel in the haunch, is nominal and the dome could withstand comparatively low internal pressures, if it were not for the tremendous dead load of the overburden. There is little re-steel tying the dome to the vertical cylinder for tensile loading. During a pressure surge it is conceived that the internal vapor pressure must overcome this dead load of the soil before rupturing the dome, or displacing it from the vertical cylinder. Therefore, the internal vapor pressure could be approximately ten pounds per square inch before serious structural damage would occur to the dome. Consequently, the hydrostatic head limit of 10 psig was recommended ⁷ and accepted by the Plants.

The tank loading limits recommended by a structural review of the 241-SX and 241-A tanks in 1955 ³ were based on working stresses considerably above those recommended by the Portland Cement Association and American Concrete Institute because it was then recognized that the concept of the hydrostatic head limitation presented severe loading conditions, primarily vapor pressure surges, which probably would not be realized in actual operation. This provided immediate storage space for self-boiling wastes under controlled conditions in the new 241-A and 241-SX storage tanks. Since that time occasional maximum pressure surges have been measured in the range of 15 to 30 percent of the hydrostatic head of contained wastes. Therefore, to determine long-time, safe-loading limits in existing facilities, it is more realistic to use allowable working stresses within the recommendations of the Portland Cement Association and American Concrete Institute. The loadings used in this study to calculate the actual working stresses in the wall of the structure could be realized continuously during the useful life span of the tank; whereas, the loads of other structures, such as buildings and bridges, seldom experience the design live loads for a continuous period of time.

B. Operating Procedures

Each Operation group should implement their own procedures to comply with the RECOMMENDATIONS. The following general conditions are suggested as a guide.

1. Initial Filling of an Unused Tank

To minimize the thermal stress in the structure, it is proposed that the tank be heated slowly. This could be accomplished by heating at either a uniform rate of temperature change or by

an incremental increase in temperature as illustrated in Fig. 6, attached. The initial temperature of the tank and liquid heel was assumed to be 70° F.

a. Uniform Rate of Temperature Change

The recommended maximum uniform rate of temperature change from ambient to boiling is 2° F per day. This uniform rate would require approximately ten (10) weeks to heat the contents of a tank to boiling temperature.

b. Incremental Temperature Increase

The recommended maximum temperature increment is 40° F and it can be accomplished as rapidly as necessary to facilitate operating procedures. The first temperature plateau should be maintained at approximately 110° F for a minimum time of four weeks; the second plateau at 40° F greater than the first plateau; the third plateau at 40° F greater than the second, etc. The last plateau at 230° F $\pm$ 10° F, will permit boiling for self-concentration.

The wastes should be held at the boiling temperatures for at least eight weeks before permitting the waste temperatures to exceed 230° F. Waste temperatures should be maintained at 220° F to 250° F so as not to exceed the vaporization pressure of the moisture in the grout located between the steel liner and the asphaltic membrane.

Heating of the contents may be accomplished by adding a calculated quantity of fresh waste by steam or other external heat source.

- c. The tank should be filled to a liquid level not to exceed the recommended working pressures for the structure, as described in the RECOMMENDATIONS and in Figures 1 through 4, attached.

2. Control of Self-Boiling Wastes

To minimize pressure and temperature fluctuations caused by sludge formation, hot spots and bumping, it is suggested that the following controls be observed:

- a. The operating temperature of the waste should be maintained between 220° F and 250° F. The maximum sludge temperature should not exceed 300° F.
- b. The concentration of the solution should be:

1. For Purex waste less than 9M sodium ion concentration (calculated) or a density of less than 1.37 as measured.
2. For Redox waste less than 11M sodium ion concentration (calculated) or a density of less than 1.68 as measured.
- c. When the liquid level is one foot or more above the top of the lowest air-lift circulator, at least one submerged circulator should be operated as long as necessary to minimize bumping.

3. Transfer of Waste

The potential magnitude of the hazard resulting from possible loss of waste from a leaking tank is reduced by the ability to transfer wastes between tanks as necessary. To minimize pressure and temperature fluctuations the following controls are proposed for the transfer of waste:

- a. Self-boiling waste should be transferred into another tank within the same tank farm. If this is an unused tank, the criteria for filling an unused tank (paragraph B-1) should be observed. If the tank has been used and has contained a two-foot or more depth of liquid at a temperature of 120° F or higher for the previous four weeks, it may be filled to a depth not to exceed the minimum allowable pressures (paragraph B-1-c) or not to exceed a temperature increase of 40° F.
- b. Waste which has stopped boiling or does not contain sufficient energy to self-boil may be transferred to a tank or tanks in the same tank farm or other tank farms such as U, TX, and TY. To minimize thermal stresses in the structure, the temperature rise in these tanks should be controlled to less than 40° F during the transfer period. If the temperature of the receiver is more than 40° F below the temperature of the waste being transferred, the transfer should be made slowly to comply with the provisions of filling an unused tank (paragraph B-1-b). A stabilization period of at least four weeks should be allowed between transfers into any one tank after a temperature rise of 40° F above the initial temperature has been obtained. No stabilization period is required when the rate of temperature rise is less than 2° F per day.

C. Explanation of Figures

1. Fig. 1, Safe-Load Curve for 241-A Type Storage Tank

This safe load curve applies only to the six 241-A storage tanks when they are operated in accordance with RECOMMENDATIONS of this report. An allowable working stress in ring tension of 16,000 pounds per square inch and 300 pounds per square inch was used

respectively for the structural steel and concrete. A temperature gradient of 23°F per foot of material thickness was used to determine the thermal loads in the structure. A maximum liquid specific gravity of 1.37 was assumed for the liquid wastes to be stored in the tank. The vapor pressure was assumed to have an instantaneous loading factor of "one" which would be for a slowly applied vapor loading. Any alteration in these bases would also alter the safe-load curve. No extrapolation of this curve, due to a change in the bases, should be made without a complete structural review by a competent structural engineer.

If the maximum vapor pressure which could be encountered in the 241-A tank when storing self-boiling wastes is defined, the safe liquid level (or storage volume) can then be determined from the safe-load curve. A plot of the combined loadings for liquid depth (hydrostatic load) and vapor pressure should always be to the left of the curve. If the maximum vapor pressure was determined to be 3.0 pounds per square inch, then the safe liquid load would be 21.5 feet at sp. gr. 1.37, and the vapor pressure would be 23.5 percent of the hydrostatic load.

2. Fig. 2 - Safe-Load Curve for 241-SX Type Storage Tank

This safe load curve applies only to the fifteen 241-SX storage tanks when they are operated in accordance with the RECOMMENDATIONS of this report. The allowable working stresses and temperature gradients were the same as those used for the 241-A tank. A maximum liquid specific gravity of 1.68 was assumed for the liquid wastes to be stored in the tank. The vapor pressure was assumed to have an instantaneous loading factor of "one" which would be for a slowly applied vapor loading. Any alteration in these bases would also alter the safe-load curve. No extrapolation of this curve, due to a change in the bases, should be made without a complete structural review by a competent structural engineer.

If the maximum vapor pressure which could be encountered in a 241-SX tank when storing self-boiling wastes is defined, the safe liquid level (or storage volume) can then be determined from the safe-load curve. A plot of the combined loadings from the liquid depth (hydrostatic load) and the vapor pressure should always be to the left of the curve. If the maximum vapor pressure was determined to be 2.5 pounds per square inch, then the safe liquid depth would be 16 feet at a specific gravity of 1.68, and the vapor pressure would be 21.4 percent of the hydrostatic load.

3. Fig. 3 - Safe-Load Curve for 241-S, BY, TX, TY Type Storage Tank

This safe-load curve applies only to the 750,000-gallon capacity storage tanks in the designated tank farms when they are operated in accordance with the RECOMMENDATIONS in this report. The allowable

working stresses and temperature gradients were the same as those used for the 241-A and 241-SX tanks. It was assumed that only non-boiling wastes would be stored in these tanks at a maximum temperature range of 180° to 200° F and therefore no vapor pressure could exist.

A "hot tank" is defined as one in which the stored liquids are at a temperature greater than the ground temperature. The liquid waste temperature in a "hot tank" should be less than 50° F above the ground temperature and should not exceed 200° F.

If the liquid specific gravity of the stored waste is defined, the safe liquid depth can then be determined from the safe-load curve for a hot or cold tank. For example, a hot, non-boiling waste at a specific gravity of 1.8 would have a safe liquid depth of 15 feet (458,000 gallons storage volume) and 17 feet (524,000 gal) for a cold waste of the same specific gravity.

4. Fig. 4. Safe-Load Curve for 241-T, U,B,C, BX Type Storage Tank

This safe-load curve applies only to the 530,000-gallon capacity storage tanks in the designated tank farms when they are operating in accordance with the RECOMMENDATIONS in this report. The allowable working stresses and temperature gradients were the same as those used for 241-A and 241-SX tanks. It was understood that only non-boiling wastes would be stored in these tanks at a maximum temperature range of 180 to 200° F and therefore no vapor pressures would exist.

A "hot tank" is defined as one in which the stored liquids are at a temperature greater than the ground temperature. The liquid waste temperature in a hot tank should be less than 50° F above the ground temperature and should not exceed 200° F. If the liquid specific gravity of the stored waste is defined, the safe liquid depth can then be determined from the safe-load curve for a hot or cold tank. For example, a hot, non-boiling waste a specific gravity of 1.8 would have a safe liquid depth of 14-feet (425,000 gallons), while a cold waste of the same specific gravity would have a safe liquid depth of 14.8 feet (451,000 gallons).

5. Fig. 5. Safe Temperature - Hydrostatic Load Curve

This safe-load curve applies to the 129 existing radioactive waste storage tanks in the 200 Areas. These tanks have an inside diameter of 75-feet and a thin carbon steel liner which is not anchored to the concrete. The difference in the geometry of the various tank bottoms has no effect on this curve. The maximum safe temperature of the tank bottom is postulated to be a parameter of the hydrostatic liquid load on the tank bottom.

Based on the maximum recommended liquid levels in Figs. 1 and 2 for 241-A and 241-SX tanks, the maximum allowable tank bottom temperatures would be 248° F and 245° F respectively. When filling and heating a tank, the plot for the hydrostatic load versus the tank bottom temperature should be to the left of the curve. For example, a tank bottom temperature of 212° F would require no hydrostatic load on the tank bottom to overcome the vaporization pressure; while a tank bottom temperature of 228° F would require a hydrostatic load of 5 psig on the tank bottom.

The instability of the tank bottom of 113-SX and 104-U could have been caused by either a vapor or liquid pressure under the steel liner, or by thermal expansion, or by a combination of these. Experiments indicate that there is adequate moisture available in the two-inch layer of portland cement grout between the steel liner and the three-ply asphaltic waterproofing membrane.¹⁴ The walls of a natural gas pocket are formed by the steel liner above, and the asphaltic membrane below the cement grout. Unless this gas pocket is relieved somehow upon heating there will be adequate moisture in the grout which, upon vaporization, could cause an unstable condition of the bottom liner.

The curve in Fig. 5 has been developed from the steam tables in which the ordinate axis is the vaporization pressure expressed as gage pressure in pounds per square inch and is equated to the hydrostatic load on the tank bottom. The abscissa axis is the corresponding saturation temperature expressed as degrees Fahrenheit and is equated to the tank bottom temperature, thus developing the safe temperature-hydrostatic load relationship.

6. Fig. 6, Recommended Rate of Temperature Rise

The recommended maximum rate of temperature rise for the liquid wastes applies to all 129 existing radioactive waste tanks in the 200 Areas. The rise is expressed both as an incremental and as a uniform rate in respect to operating time of the tank to simplify operating procedures. A plot of recorded maximum waste temperatures versus time should be to the right (or below) the respective curve to maintain a safe rate of heating. The purpose of this curve is to maintain a safe temperature gradient across the tank structure to minimize cracking in the concrete and to minimize the thermal stress in the steel liner plate without interrupting plant production schedules. Derivation of this temperature gradient may be obtained from the studies on transient heat flow.^{1,2, 15}

It is recommended that a 50,000-gallon liquid heel at ambient ground temperature be placed into empty tanks to reduce the initial thermal shock of higher temperature liquids. The heel will reduce the thermal shock on the structure when inducing higher temperature wastes and provide a slow temperature rise of the tank bottom.

The uniform rate of temperature increase of the stored wastes should not exceed 2° F per day from ambient ground temperature to boiling. The maximum incremental increase should not exceed 40° F at any one time, although this increment could be fast. The minimum time interval of four weeks is required to permit the temperatures in the outer surface of the structure to approach the temperatures of the inner surface. After the minimum time presented on the curve has elapsed, a new temperature increment may be achieved by adding fresh high-level wastes.

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FIG 1. SAFE LOAD CURVE FOR 241-A TYPE STORAGE TANK

FIG. 2. SAFE LOAD CURVE FOR 241-SX TYPE STORAGE TANKS

FIG 3. SAFE LOAD CURVE FOR 241-S, BY TX, TY TYPE STORAGE TANK

FIG 4. SAFE LOAD CURVE FOR 241-T.U.E.C. BX TYPE STORAGE TANK

FIG. 5. SAFE TEMPERATURE-HYDROSTATIC LOAD CURVE
(241-A, SX, T, U, B, C, BX, BY, TX, TY, S TYPE TANKS)