UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 12 1978

Mr. Richard Doyle
Werner & Pfleiderer
160 Hopper Avenue
Waldwick, New Jersey 07463

Dear Mr. Doyle:

SUBJECT: STAFF EVALUATION OF RADWASTE TOPICAL REPORT

The staff has completed its evaluation of your topical report on Radwaste Volume Reduction and Solidification and finds it is acceptable for reference in licensing applications. A detailed evaluation of your report is enclosed.

The results of our fire protection review indicate that responsibility for the protection would be left with the individual applicant who would reference your system. As such, the particular nuclear plant installing your system would be subject to a complete fire protection review, including the installation, and would be required to meet existing rules and regulations.

A copy of this letter and its enclosure should be included in the front of the final revision to your report. Sixty (60) copies of this proprietary revision and twenty-five (25) copies of the non-proprietary version should be sent to the staff for our final distribution.

Sincerely,

Karl Kniel, Program Manager
Light Water Reactors Branch No. 2
Division of Project Management

Enclosure:
As Stated

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TOPICAL REPORT EVALUATION OF
WERNER & PFLEIDERER REPORT
"RADWASTE VOLUME REDUCTION AND SOLIDIFICATION SYSTEM"
NOVEMBER 1976

1.0 Summary of Topical Report

The report describes the design and operation of the Werner and Pfleiderer Corporation Radwaste Volume Reduction and Solidification System (VRS) which combines radioactive solid waste with an asphalt binder for packaging and eventual offsite shipment to a licensed burial facility. During operation of the VRS, "wet" solid wastes (evaporator bottoms, spent resin, filter sludge, etc.) are evaporated to dryness in the extruder/evaporator while concurrently mixing the residual radsalts with asphalt, thus achieving a degree of waste volume reduction. In addition to design information, the report includes a discussion of the research, development, and operational experience of systems similiar to the VRS in installations in Europe.

The principal findings in the report are: (1) the VRS is capable of safely processing wet solid radioactive wastes generated by light water reactors, (2) the solid waste product is a homogeneous mixture of finely dispersed radsalts in an asphalt binder, and is absent of free water, (3) the VRS is capable of achieving waste volume reduction factors ranging from 1 to 20, (4) the decontamination factor (DF) for non-volatile species of iodine (i.e.,iodide and iodate form) is estimated to be at least 500 based on measured DFs for other radionuclides, and (5) the annual release of radioactive materials in gaseous effluents is expected to be insignificant relative to other sources within the plant because of the decontamination factor of the extruder/evaporator, the "stripping" effect of the VRS integral condenser on any materials which may be carried over in the steam, and the venting of the distillate collection system through a high efficiency particulate air (HEPA) filter and charcoal adsorber (2 inch bed) prior to release to the environment. Werner and Pfleiderer Corporation is currently conducting tests to provide measured DFs for iodine processed in an extruder/evaporator.

The staff has also evaluated the radiation protection features described in the Topical Report entitled "Radwaste Volume Reduction and Solidification System" submitted by Werner and Pfleiderer Corporation. The system described utilizes the same basic technology as systems on which operational experience has been accumulated in installations outside of the United States. The radiation protection features described in this report are consistent with the guidelines of Regulatory Guide 8.8, "Information Relevant to Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable". These features are intended to assure that occupational radiation exposures to personnel involved with the operation, maintenance, and inspection of the radwaste system are maintained as low as is reasonably achievable.

2.0 Summary of Regulatory Evaluation

2.1 Effluent Treatment Systems

In the staff evaluation of WPC-VRS-1 (WPC-VRS-1P Proprietary), it reviewed: (1) the VRS design description including flow schematics and piping and instrumentation diagrams (P&IDs), (2) the VRS method of operation, (3) the extruder/evaporator operating experience at European facilities, (4) the VRS quality group classification, (5) the quality assurance program for the design, construction, and testing of the VRS, (6) the process control program for the VRS to assure that the proposed method of solidification is capable of solidifying the range of constituents expected to be present in the solid wastes, (7) the VRS design basis input waste volumes, and (8) the interfaces with other plant systems.

The design description of the VRS in the report is based on a single VRS-T120 extruder/evaporator which is a twin-screw machine having an inside bore diameter of 120 millimeters for each screw. The VRS combines volume reduction and solidification processes by simultaneously feeding measured quantities of wet solid waste (spent resin, filter sludge, evaporator bottoms, etc.) and hot asphalt to the extruder/evaporator which evaporates the free water, mixes the remaining radsalts with asphalt, and dumps the mixture to a waiting 55 gallon drum on a turntable. The hot mixture is allowed to cool before final capping and interim storage prior to shipping. The extruder/evaporator is equipped with steam domes with integral condensers and the distillate is directed to a downstream distillate collection and oil filtration system for recycle back to the liquid radwaste system. In addition to the distillate collection and oil filtration system, the VRS scope of supply includes the waste and asphalt feed systems, drum turntable, drum ventilation hood, capper, crane, swipe station manipulator, and cooling water and steam supply systems.

Even though the extruder/evaporator is manufactured in West Germany, the design, construction, quality group classification, and quality assurance provisions for the VRS are in accordance with Branch Technical Position — ETSB No. 11-1 (Revision 1) and are, therefore, acceptable. The conformance of the seismic design criteria for the building housing the solid radwaste system to the above BTP will be determined for each individual application.

In order to assure complete solidification of the variety of constituents expected to be present in the solid wastes and the absence of free water, Werner and Pfleiderer Corporation has developed a process control program which establishes a set of process parameters for operation of the VRS.

The process control program is in accordance with the guidance set forth in Branch Technical Position — ETSB No. 11-3 and, therefore, is acceptable. The process control program is based on tests performed with the following simulated waste formulations (Wt. %): (1) 20% sodium sulfate, (2) 10% boric acid, (3) 50% bead resins, (4) 50% powdered resin, (5) 60% filter sludge, (6) liquid waste (10% solids), and (7) decontamination solution (10% solids). In support of the above program, Werner and Pfleiderer Corporation (WPC) has also processed samples containing the following contaminants: (1) sodium perborate, (2) EDTA, (3) hydrazine, (4) ferric oxide, (5) sodium hydroxide, (6) sodium chloride, (7) diatomaceous earth, (8) phosphoric acid, (9) arsenic trioxide, (10) organic arsenicals, and (11) filter aid. For process control, WPC places a limit of 1% oil and 1% organic contaminants in the waste feed stream.

The VRS-T120 has a rated evaporative capacity of approximately 32 gallons/hour and, thus, has limited processing capacity. Based on expected waste feed-stream flow rates for 3400 MWt boiling and pressurized water reactors, we estimate VRS utilization factors of approximately 45% for a BWR (deep bed condensate demineralizers) and 37% for a PWR (deep bed condensate demineralizers). Thus, the availability of the VRS is dependent on the high reliability of the extruder/evaporator. High extruder reliability has been demonstrated in domestic plastics industries under more demanding conditions.

WPC reports that in the plastics industry the extruder operates continuously for 358 days per year. Thus, we consider the processing capacity of the VRS to be capable of meeting the demands of the plant.

The report defines the equipment normally supplied by WPC as a part of the VRS as well as the systems that will interface with the VRS. The VRS will interface with the chemical adjustment system, liquid radwaste system, floor drain system, cooling water system, and heating, ventilating, air conditioning (HVAC) system. The report states that chemical adjustment of wet solid waste and surge capacity for anticipated wastes are to be provided in the liquid radwaste system by others (utilities/architect engineer).

2.2 Radiological Assessment

The entire Werner and Pfleiderer Corporation — Volume Reduction and Solidification (WPC-VRS) system is designed to minimize operator and maintenance radiation exposures. The close clearance of the twin-screw extruder/evaporator provides the system with a self-wiping and, thereby, self-cleaning feature. This prevents radwaste buildup on the screws and limits the total radwaste inventory in the extruder/evaporator to approximately one-half gallon of radwastes. The resulting radiation levels from the extruder/evaporator will range from 50 to 400 mR/hr during operation to less than 10mR/hr during shutdown. The system fills and caps the waste drums remotely. In response to our question on how the "as low as is reasonably achievable" philosophy has been incorporated into the design features at WPC-VRS, the applicant provided the following responses: (1) all major components of the WPC-VRS system are specified for a 40-year operating life; (2) the extruder/evaporator, crane, all process pumps and valves, and all potentially radioactive components will be remotely operated and controlled from the main control panel; (3) system components will have flush connections for removal of radioactive materials prior to maintenance work; and (4) tanks, pumps, piping, valves, and other components in contact with radioactive materials will be fabricated of stainless steel to facilitate decontamination.

The WPC-VRS system is designed to minimize crud deposition. In addition to the self-cleaning feature incorporated into the design of the extruder/evaporator, the applicant has incorporated the following design features: (1) no flat-bottomed tanks are used for the collection of radioactive process streams; (2) pipe runs are designed to be as short as possible to minimize crud traps and blockage; (3) reliable equipment is used so that maintenance and operator attention is minimized; and (4) welded pipe is used whenever possible. These features are in accordance with those contained in Regulatory Guide 8.8 with respect to crud reduction to minimize personnel exposure.

The layout of the WPC-VRS system is arranged such that all operation is from the main control panel which is located in a low radiation zone. The operator can observe filling and capping operations

through shielded windows and/or a closed circuit television system. Access to non-radioactive components for maintenance is from clean areas only. All major components will be located in separate cubicles for ease of maintenance and operations. Pumps and tanks containing radioactive material will be located in separate shielded cubicles. Wherever feasible, components located in high radiation zones will be designed for remote retrieval into lower radiation zones for maintenance purposes.

The ventilation system will be the responsibility of the power plant in which the WPC-VRS system is installed. However, the Werner and Pfleiderer Corporation will require that the flow of air be directed from areas of lower potential contamination to areas of higher potential. In addition, a vent hood will be provided over the discharge barrel. This will be connected directly to the exhaust ventilation system and will exhaust contaminants through HEPA filters and activated charcoal prior to dilution in the plant stack and discharge to the environs. These features are intended to minimize the radiation exposure to personnel from airborne contaminants and are in conformance with the guidelines of Regulatory Guide 8.8.

In response to staff questions regarding annual man-rem estimates for the WPC-VRS system, the applicant has provided an estimate of the dose rates, occupancy factors, and exposures associated with the various operations of the WPC-VRS system. Werner & Pfleiderer estimate that the total exposure resulting from operation, maintenance, and inservice inspection of the WPC-VRS system will be between 5.8 and 11.3 man-rems per year. These values are based on remote operation of the system from the operator's control panel, the reliability of the system, and the self-cleaning aspect of the extruder/evaporator. Similar systems utilizing the same basic technology have been operating in installations worldwide for over 30 unit operating years. Operating experience from these units indicates that the system will require only minimal maintenance over the plant's 40 year design life. In addition, there have been no overexposures of personnel during operation and maintenance of these systems over their combined 30 year operating history. Based on these data, and the fact that the bases for Werner and Pfleiderer's exposure estimates are consistent with the acceptance criteria contained in Section 12.4 of the Standard Review Plan, we find the applicant's exposure estimates acceptable.

Based on the information presented in the Topical Report and on the responses to our review questions, the staff finds Werner and Pfleiderer's submittal acceptable. The design features are consistent with the guidelines of Regulatory Guide 8.8 and are intended to maintain radiation exposures as low as is reasonably achievable.

2.3 Accident Analyses

We have evaluated the off-site radiological consequences of a postulated accidental release of radioactivity from the proposed system. The burning of the process products is considered to be the most significant means of generating airborne radioactivity in a design basis accident.

Since the end product represents the largest inventory of material that can be contained within the system, complete burning of the entire contents of a storage drum containing the end product is considered to be a limiting event for the radwaste volume reduction and solidification system.

The accident was analyzed assuming a maximum feed activity concentration of 90 Ci/m^3, a volume reduction of 20, and complete filling of the storage drum. The end product contained various fission products which were assumed to all become airborne after burning. With an assumed off-site x/Q value of 10^{-3} seconds/m^3, the calculated thyroid and wholebody doses are 14 and 5 rem, respectively. These dose values are well within the exposure guideline values in 10 CFR Part 100. On the basis of our conservative evaluation of the radiological consequences of a severe accident to the proposed system, we conclude that the radwaste volume reduction and solidification system is acceptable.

For each application referencing WPC-VRS-1, dose analyses will be performed where the atmospheric dispersion conditions or the feed activity concentration are greater than assumed in this SER to determine acceptability for that specific application.

2.4 Fire Protection

We find the fire protection design features incorporated into the W&P process equipment acceptable. We also accept the fire protection measures that W&P recommends that their customers incorporate into the waste processing facility design. We will require these measures to be interface requirements for applicants referencing the W&P Radwaste Volume Reduction and Solidification System Topical Report. Further, in accordance with BTP 9.5-1, we will require applicants utilizing the W&P radwaste processing system to include in the plant fire hazards analysis information that demonstrate how safely related systems will be protected from possible fires associated with the combustibles contained in W&P system.

W&P provides equipment for handling liquid asphalt which conforms to the applicable requirements of NFPA 30, "Flammable and Combustible Liquids Code." This is a conservative approach since the process asphalt temperature is over 150° F below its flash point. W&P recommends that their customers design waste handling facilities to meet NFPA 30 with respect to the following:

1. Asphalt storage tank foundation design;
2. Eliminating sources of potential ignition;
3. Ventilation provisions;
4. Drainage provisions;
5. Fire control provisions; and
6. Electrical equipment requirements.

In addition, W&P recommends that their customers incorporate the following features into the facility design:

1. Provide a dike around the asphalt tank capable of containing the complete contents of the tank.
2. Direct vents, overflows, and drains from indoor asphalt storage tanks to the outdoors.
3. Provide a fixed automatic sprinkler system or suitable alternate system in indoor areas where liquid asphalt or the molten asphalt incorporated waste product is handled or stored.

The only other significant fire hazard associated with this process (besides the asphalt) is a forced oil lubrication system provided for the gear box. Design and operating considerations used to control this fire hazard are three fold:

1. Limiting total oil inventory in the system to less than 75 gallons.
2. Use of high ignition point (over 500°F) lubricating oil, and maintaining operating temperature of approximately 150°F.
3. Use of all welded construction.

We find the fire protection design features incorporated into the W&P process equipment acceptable. We also accept the fire protection measures that W&P recommends that their customers incorporate into the waste processing facility design. We will require these measures to be interface requirements for applicants referencing the W&P Radwaste Volume Reduction and Solidification System Topical Report. Further, in accordance with BTP 9.5-1, we will require applicants utilizing the W&P radwaste processing system to include in the plant fire hazards analysis information that demonstrates how safety related systems will be protected from possible fires associated with the combustibles contained in the W&P system.

3.0 Regulatory Position

The Werner and Pfleiderer Corporation Report WPC-VRS-1P and its amendments provide an acceptable basis for the following: (1) the VRS can safely process wet solid wastes at anticipated waste feed rates for a 3400 MWt light water reactor and the adequancy of the capacity is dependent upon the reliability of the extruder/evaporator; (2) the design, construction, quality assurance provisions and quality group classification of the VRS are in accordance with BTP-ETSB No. 11-1 (Revision 1); (3) the process control program for the VRS to assure complete solidification and the absence of free water in processed waste is in accordance with BTP-ETSB No. 11-3, and (4) the design features are consistent with the guidelines of Regulatory Guide 8.8 and are intended to maintain radiation exposures as low as is reasonably achievable.

The capability of the plant radioactive waste treatment systems to meet the requirements of Appendix I to 10 CFR Part 50 is site dependent and will be evaluated for individual license applications. In addition, the packaging and shipping of all processed wastes in accordance with the applicable requirements of 10 CFR Part 71 and 49 CFR Parts 170-178 will be determined for individual license applications.

The staff concludes that report WPC-VRS-1P, including amendments, is acceptable for reference in future license applications for light water reactors. Any application incorporating this report by reference should include all deviations from this report. License applications for other than light water reactors which desire to reference this report will be evaluated on a case-by-case basis.

Report WPC-VRS-1 is an acceptable nonproprietary summary of proprietary report WPC-VRS-1P.

AMERICAN NUCLEAR INSURERS
EVALUATION OF WERNER & PFLEIDERER'S
RADWASTE VOLUME REDUCTION AND SOLIDIFICATION SYSTEM

American Nuclear Insurers (ANI — formerly NEL-PIA), the largest underwriter of nuclear property and third party liability insurance in the U.S., has completed a thorough review of the WPC-VRS system. They conclude that the system is acceptable for normal insurance coverage, given adherence to certain specified process and plant design criteria. These criteria are consistent with WPC's basic design philosophy and with the standards normally applied to nuclear construction under the National Fire Code (published by the National Fire Protection Association). ANI's recommendations dealt with, among other things, sprinkler system design, air filtration, process interlocks, and alarm system design. Of course, many of these items transcend WPC's normal scope of supply on a radwaste system and are involved with the design of the radwaste building itself. They therefore are site specific, becoming a part of the design criteria for the entire plant fire protection system.

ANI's overall assessment of the WPC-VRS system is best summarized by the opening paragraphs of their April 21, 1978 letter to WPC, submitted at the conclusion of their review.

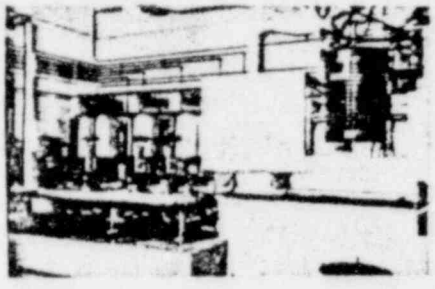
> "Thank you for your time and cooperation in assisting American Nuclear Insurers in completing our review of the Werner & Pfleiderer radioactive waste volume reduction and asphalt solidification system.
>
> The fundamental basis for our review has been to weigh the risks versus the benefits of your system and to assess our potential incremental increase in exposure to loss from both a 3rd party liability and direct property damage posture. The benefits to be derived from the use of the Werner & Pfleiderer System over the use of other systems at nuclear power plants relate primarily to the volume reduction aspects of the system which we feel will result in lower inplant radiation exposures as well as a decrease in the number of shipments of radioactive wastes. In addition, asphalt encapsulated radioactive wastes appear to provide a greater degree of leach resistance than other encapsulated waste forms thus providing greater containment during ultimate disposal. Since the primary risk introduced into the plant centers around the combustible nature of the encapsulated media, (our) recommendations focus on reducing this aspect, both by plant design and process protection. We realize that Werner & Pfleiderer is not responsible for the completion of (our) recommendations, however, their completion is required before ANI can accept your system at plants we insure . . ."

ANI's design criteria are available on request. For a thorough discussion of these criteria and their relationship to your radwaste facility, please contact Nuclear Products, Werner & Pfleiderer Corporation.

WPC-VRS SYSTEMS HAVE A PROVEN PERFORMANCE RECORD IN NUCLEAR RESEARCH CENTERS, FUEL REPROCESSING FACILITIES AND THE WORLD'S LARGEST OPERATING REACTORS

VRS INSTALLATIONS	NUMBER OF UNITS	DELIVERY OR START-UP DATE
CEA, Marcoule, France	2*	1965
CEA, Cadarache, France	1*	1969
KARLSRUHE, West Germany	2*	1972 - 73
BORSSELE (PWR), Holland	1	1974
ATUCHA (PHWR), Argentina	1	1974
EUROCHEMIC, Mol, Belgium	1	1975
NECKARWESTHEIM (PWR), West Germany	1*	1975
AECL, Chalk River, Canada	1	1976
UNTERWESER (PWR), West Germany	1*	1977
GOESGEN (PWR), Switzerland	1	1977
LAGUNA VERDE (BWR), Mexico	2	1978
Japan	2	1978 - 79
MIDLAND (PWR), United States	1	1978
France (Reprocessing Plant)	1	1979
SKAGIT (BWR), United States	1	1980
IRAN I & II, Iran	2	1980 - 82

* Retrofit installation — replaced cement system. For more information see Retrofit brochure.



NUCLEAR RESEARCH CENTER
KARLSRUHE, WEST GERMANY

1,300 MWe PWR
UNTERWESER, WEST GERMANY

The WPC-VRS system will produce significant savings when compared to non-volume reduction systems.

1. The VRS system will reduce your costs for binder, containers, transportation, and burial by $400 thousand to $1 million per year.
2. The VRS system requires fewer operating and maintenance personnel. In addition, its proven reliability and tolerance to upset conditions reduces man-rem exposures.
3. The VRS system requires minimal building space. Its volume reduction feature allows the space allocated to empty and filled containers to be minimized.
4. The NRC's acceptance of the Topical Report on the WPC-VRS system allows you to reference this document in your SAR's. This saves countless engineering hours devoted to describing the operating characteristics of your radwaste system.

This system now has 21 units in operation or on order at 16 locations worldwide. Over 50 system years of reliable, low-maintenance operation have now been logged.

WPC AND VRS . . . A COMBINATION YOU CAN DEPEND UPON TO MANAGE YOUR RADWASTES, SAVE MONEY, AND MEET STANDARDS WITH CONFIDENCE AND RELIABILITY FOR BOTH RETROFIT AND NEW INSTALLATIONS.

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