AWMA

Radioactive Waste Management Associates

Presentation Before
Panel on the Waste Management System
Nuclear Waste Technical Review Board
by
Marvin Resnikoff, Ph.D.
Radioactive Waste Management Associates
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Thank you for inviting me to appear before the Panel on the Waste Management System. I'm usually brought on at this time of the day to liven up the proceedings and I hope I don't disappoint you. Transportation of spent fuel and high-level waste is an important topic. From a political perspective, transportation of radioactive waste touches more people than the generation or disposal of radioactive waste. The first overhead, which I clipped from a Hudspeth County, Texas newspaper just last week, shows what local people feel about transportation safety. As you see local people perceive transportation as dangerous and government agencies as covering up this danger.

I've worked on this issue, primarily at the state and local level, but also for public interest groups such as the Sierra Club and Greenpeace, for the past 22 years and know many of the presenters before you today. This work first began in 1975 when I assisted the New York Attorney General in a federal court suit against the Nuclear Regulatory Commission (NRC) regarding shipments of plutonium from West Valley, New York out of Kennedy Airport. I should also say that we are assisting the State of Utah in its petition before the Nuclear Regulatory Commission regarding a proposed private dry storage facility at Skull Valley, Utah.

If a centralized storage facility or waste repository opens, a large number of high-level waste shipments will begin to move, a major escalation of the present number of shipments. As you see by the second overhead, approximately 80 spent fuel shipments per year have occurred since 1979, but as many as 3,000 shipments per year, if all went by truck, would occur when a centralized waste facility opens. I probably don't have to emphasize that most reactors are located in the East (3rd overhead) and Nevada and Utah are located in the West, so shipments would pass through many states and many urban areas.

I would like to focus on four topics this afternoon:

- **Physical testing** of the new generation of shipping casks is needed to benchmark computer programs. Generally, physical tests of ¼ scale models and computer

Marvin Resnikoff, Ph.D. ♦ Senior Associate

~~306 West 38th Street, Room 1601 ♦ Telephone (212) 629-5612 ♦ Fax (212) 239-8373~~
525 WEST 26TH STREET, RM. 3?
NEW YORK, NY 10001
TEL 212 620-0526 FAX 212 620-05??

simulation tests of full-scale casks have satisfied the NRC. But this new generation of casks is radically different than the old. New rail casks will hold up to 24 PWR fuel assemblies (the Holtec International HI-STORM casks will hold up to 32 PWR fuel assemblies) compared to the IF-300's 7 PWR fuel assemblies. These casks hold more than a critical mass of fuel (i.e., more than 17 PWR fuel assemblies) and weigh as much as 142 tons plus the additional weight of the rail car. I'm not suggesting that every cask be physically tested, just one full-size cask of this new generation of casks.

Physical tests for the TRUPAC cask, used for plutonium-contaminated waste from Department of Energy (DOE) facilities, provided important information that was not seen by computer modeling. Particularly, grit formed in the seal during the drop test allowing greater than permissible releases. As a result, the seal was redesigned. While I realize that the flexible TRUPAC containment is entirely different than a Type B high-level waste cask, I'm using this example to show the importance of information that can be gleaned from physical tests.

- **Radiological emergency planning and equipment.** Local emergency personnel, the first responders at the scene of an accident, must be trained and equipped for a radiation-related accident. First responders must be able to recognize the type of shipments, be able to read shipping manifests, need to determine the extent of radiation spread, seal off the accident scene, until more knowledgeable assistance arrives, and handle accident victims. Most first responders are volunteers and the turnover rate is high. Therefore there is a continual need for training programs.

- **Environmental impact statement on spent fuel transportation.** The NRC needs to prepare a new environmental impact statement (EIS) on transportation of spent fuel. The last transportation EIS appeared in 1977 and much has changed since that time. This point is discussed at some length below.

- **DOE repository requirements and private storage systems.** DOE repository requirements must be coordinated with new privately-developed dry storage casks and waste management systems. While NRC regulations require cask developers to ensure that DOE requirements are met, other than vague assurances, specific information on exactly how each cask will meet DOE specifications does not appear in the Topical Safety Analysis Reports (TSAR) of the cask developers Holtec International and Sierra Nuclear and the NRC has not requested further information. The State of Utah is greatly concerned about this aspect of the Private Storage Facility (PSF) application for the Skull Valley spent fuel storage facility since this relates to how easily the proposed temporary storage facility can be decommissioned.

Several years ago I suggested to the NRC that the Commission needs to do a new EIS on transportation, that the previous EIS, NUREG-170, was inadequate and that some state would eventually take the NRC to court on the issue. I raised this issue again April in Atlanta and was heartened to hear that the NRC would be doing an EIS. But when I talked to Charlie Haughney again in August, he backed off that statement and said that the NRC was only **considering** doing an EIS and that I should send him a letter detailing why an EIS is needed. I'm going to detail here the reasons why an NRC EIS on transportation is needed. My recommendation to the Board is to strongly and unequivocally recommend to Congress that a new spent fuel transportation EIS is needed and that Congress fund such a study. In my opinion, both the probability and consequences of accidents involving irradiated fuel have changed since NUREG-170 (4th overhead).

1) **Degradation of fuel cladding.** NUREG-170 is premised on reprocessing of irradiated fuel, not dry storage at reactor sites. Under the previous EIS, irradiated fuel would be stored under water in pools for a short period and then individual fuel assemblies would be shipped by truck (1 PWR or 2 BWR) or train (7 PWR). On the other hand, long-term dry storage may degrade fuel cladding. The maximum cladding temperature for dry storage within a VSC or NUHOMS concrete cask can reach as high as 380 °C. Two examples of dry storage are the NUHOMS dry storage system, with 24 PWR fuel assemblies within a horizontal canister within a concrete box (5th overhead). Another example is the VSC-24 where the canister stands vertical within a concrete silo (6th overhead). Convective air currents within air ducts cool the canister. A common feature of these systems is the concrete wrap, approximately 3 feet, which serves to insulate the canister and raise the internal temperature. As seen in the 7th overhead, the internal temperatures for both concrete systems is much higher than for the TN-40 cask, which is an all-metal cask. Unlike an operating power reactor, the pressure within a fuel rod is not countered by pressure within the dry storage canister. This outward pressure is responsible for creep corrosion cracking of fuel cladding. (8th, 9th overhead) During transportation, weakened cladding increases the likelihood of impact and burst rupture of fuel cladding in a severe accident.

2) **Location of severe accidents.** NUREG-170 assumes that severe accidents are more likely in a rural area. This can be seen in the 10th overhead. As you see, more severe accidents, severity category VIII, are assumed to be .9/.05 or 18 times more likely in high population zones than low population zones, whereas the reverse is true for low severity accidents, severity category I. This assumption, based on subjective judgment of where high velocity impacts are likely to occur, is incorrect. For the State of Nevada I reviewed 40 severe rail and highway accidents, selected for analysis only by the fact these had been previously analyzed by the NTSB. The 40 locations reviewed are shown on the 11th overhead. Major rail accidents occur near upgrade/downgrade

where brakes fail. The rail accidents in Helena, Montana and Bakersfield, California are two examples. As you see by the overheads, these severe accidents appear to primarily occur in suburban and urban, not rural, areas. Further, NUREG-170 does not appear to account for long duration fires in stating that severe accidents occur in rural areas. Urban areas have major fuel and flammable material requirements.

3) **Impact.** NUREG-170 and the Sandia reports upon which it is based, translate real accident velocities into the corresponding IAEA hypothetical accident conditions, 9 m foot drop onto a flat unyielding surface. The translation is carried out by using elasticity theory which is entirely inappropriate for the severe accidents that could release radioactive materials from a type B cask. Clearly a cask smashing into a concrete bridge abutment is not like two billiard balls colliding.

4) **Fire Temperature.** The corresponding translation for fire temperatures was not considered by NUREG-170. That is, translating heat inputs from real accident temperatures into heat inputs at 800 °C, the regulatory temperature. In the 12th overhead, we have calculated flame temperatures for actual materials involved in accidents with associated fires. The fire temperatures can greatly exceed the hypothetical fire temperature, 800 °C and also greatly exceed a ½ hour duration. An analysis of real accidents would show that the total heat input to a cask could greatly exceed the heat input from a ½ hour fire at 800 °C.

5) **Accident Rates.** The Sandia database for accident severities is extremely thin, based on two months of two-lane Texas highway data from the year 1969, supplemented by additional data from North Carolina. Further, certain severe accidents were not included. This database must be expanded to include higher accident speeds on today's interstate highways. We also question the objectivity of Sandia's work. Under previous direction, Sandia appeared to be primarily concerned with showing that transportation was safe, rather than objectively analyzing the facts. A book could be written on their film on cask safety, a blatant propaganda piece.

   Drops off bridges were not included in the Sandia database and should be. While admittedly rare, severe accidents are also rare. Including drops would increase the probability of severe accidents. Two striking examples are the Mianus (I-95) and Schoharie (NYS Thruway) bridge collapses. The Mianus bridge collapse involved loss of a bridge span at night. Several vehicles sailed off into the night, dropping 80 feet into the abyss. The impact velocities can be quite high, as shown in the 13th overhead.

6) **Human error.** NUREG-170 assumes a perfect container and perfect operation in an imperfect world. As you are well aware, casks are not necessarily built according to design (NAC-4; VSC-24 at Palisades). In the case of the VSC-24 cask, the NRC uncovered major QA problems involving welds at cask manufacturers, who were not familiar with NRC QA regs. Even though the VSC-24 cask Certificate of Compliance requires a procedure for unloading storage casks, an improperly welded cask used at Palisades, which the NRC directed to be unloaded, has still not been unloaded, four years after the NRC directive. There appear to be major difficulties in unloading a dry storage cask because of the internal heat. And workers sometimes make mistakes (water-filled NLI-1/2 at Duke Power; high heat assembly from Haddam Neck to Battelle Columbus). Yet human error is not factored into accident probabilities in NUREG-170.

   The accident at Battelle Columbus relates to a point previously raised by a Board member, the need for consistent accident statistics. The 1980 Battelle accident involved a shipment of spent fuel with too high a heat output for the cask. As a result the cladding degraded and uranium oxidized. When the shipping cask was inserted in the fuel pool and opened, a black cloud of fission products was released into the pool, contaminating the pool and setting off radiation monitors. This accident was quite similar to a low-level waste accident that took place at Barnwell, South Carolina in 1990, when a type B cask, supposedly dry, was opened and released 75 gallons of contaminated water into the burial pit. This low-level waste accident/incident appears in the RMIR database and is counted as a low-level waste accident/incident, but the high-level waste accident/incident at Battelle is not recorded as a high-level waste shipping accident/incident.

   As another example, type B casks are also used to house and ship radiography sources. In an accident in Texas, a type B radiography cask fell out the back of a pickup truck, was hit by a following car and released its contents. This is not listed by Sandia as a type B cask accident, with a release of contents.

   The Board should recommend that a consistent high-level and low-level accident/incident database be developed, which clearly shows the accident/incident rate as a function of miles traveled.

7) **Cask Capacity.** The capacity of the present generation storage/transfer casks is much greater than assumed in NUREG-170. Newer casks may hold up to 24 or even 40 (TN-40) fuel assemblies. An accident involving this huge inventory of irradiated fuel in an urban area has not been analyzed.

In addition, these casks will hold more than a critical mass of fuel (17 PWR assemblies). If the nuclear industry is successful in lobbying for burnup credit, it then becomes essentially a management decision on the quantity of fissionable material within each cask, an additional source of human error. A criticality event, in which fuel is re-arranged and water enters the cask, would be far outside the envelope of consequences assumed in NUREG-170.

8) **Sabotage.** Since the Nuclear Regulatory Commission and Sandia Laboratories conducted studies of the effect of sabotage on metal shipping casks, the threat has become more real and the technology more sophisticated. No sabotage studies have been done for concrete casks. Irradiated fuel storage casks, while extremely sturdy, can be compromised by anti-tank weapons or commonly available explosive devices. A simple conical charge weighing 743 grams, 15 cm in length, can penetrate 355 mm of mild steel (lead would be simpler) with a hole diameter 45 mm. These devices should be readily available since they are used by the oceanographic industry for cable cutters, construction contractors for drilling aids and the steel industry for tapping open-hearth furnaces. To create greater mischief, the conical shaped charge can be combined with an incendiary pellet. After the explosive punches a hole through metal, the incendiary pellet is pulled through the blast hole and burns at 1649 ^{O}C. This would serve to fragment fuel rods and pellets, vaporize semi-volatile radionuclides such as cesium, and release radioactivity from the cask due to overpressure.

   A modern shoulder-fired anti-tank weapon can penetrate over 16 inches of armor plate. The most common shoulder-held anti-tank weapons have effective ranges over 500 meters, with sights for night use. The Milan and TOW2 anti-tank weapons have ranges over 1 km and can penetrate over 1 meter of steel. The VSC-24 is constructed of only 2 1/2 inches of steel plate (1 inch in the inner container and 1 1/2 inches forming the inside of the concrete silo) and could be easily punctured.

   The NRC argument that certain targets are preferable is not persuasive. Imagine the Olympics in Salt Lake City in the year 2002 and rail casks moving through downtown Salt Lake City at the same time. But this is only one of many scenarios. The truth is several foreign governments and nationals (World Trade Center) and domestic militant groups (Oklahoma City) have grievances against the United States government and radioactive waste is a high visibility target.

9) **Cask Burial.** As shown in calculations for the TN-40, if a cask is buried in sediment, it can rapidly overheat. The time period of concern is tens of hours. Thus, a successful salvage operation must be rapid, which is not simple for a 125-ton object.

The HI-STORM 100 built by Holtec International is 142 tons, not including the train carriage.

10) **Sensitivity Analysis.** Finally, NUREG-170 and its supporting Sandia databases, do not have sensitivity analysis. An update should contain a sensitivity analysis.

For the above reasons, I feel strongly that **a new NRC EIS on transportation is needed and that Congress should fund this work.**

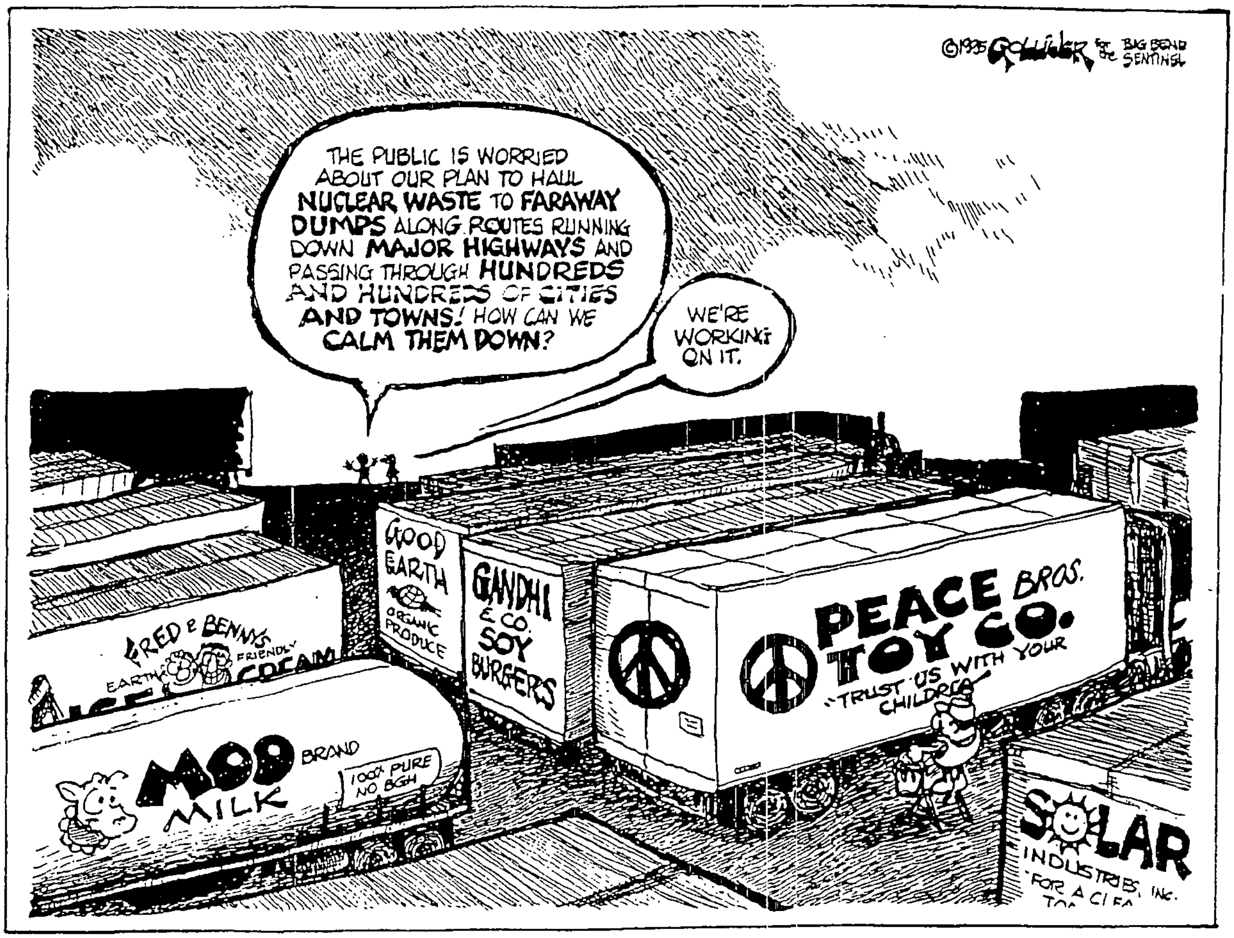
I'd like to return to one of the issues I raised at the beginning, the compatibility between DOE requirements and private storage casks. I mentioned we are assisting the State of Utah in its petition before the NRC regarding a proposed temporary storage facility in Skull Valley, near Salt Lake City. In the process, we investigated new combined use transport/storage systems proposed by Holtec International and Sierra Nuclear. Fuel is placed in internal canisters and welded shut. These canisters in turn are put into transportation overpacks or storage overpacks. The PFS storage application is before an NRC hearing panel. I won't lay out the State's objections here; these will appear in a petition submitted November 24th. But the question of whether the casks, the HI-STORM 100 or Transtor casks are compatible with DOE requirements is an important issue. If these canisters and transport casks are not compatible with DOE requirements, then the canisters must be opened and the fuel transferred. Even though the proposed Utah storage facility will handle a projected 40000 metric tons of spent fuel, the proposed facility does not have provisions for handling damaged casks, canisters or fuel. Clearly it is preferable not to open the canister, that is, to ship an intact canister to the repository and have it fit into a DOE disposal overpack. And DOE should have the capability of handling private casks. NRC regulations require compatibility but the Holtec and Transtor TSAR's that we have reviewed are quite vague. And NRC staff have not asked further questions. **The Board should recommend that private transport/storage systems being designed be compatible with DOE repository requirements and that NRC enforce appropriate regulations to that end.**

Along the same line, fuel with gross cladding defects will not be accepted by DOE for disposal. Fuel with gross cladding defects will have to be packaged. But how will DOE know? The present casks are welded shut, and the NRC has not stated how testing of fuel assemblies will be carried out. Clearly it will be necessary to inspect representative fuel assemblies, but to my knowledge, there are no NRC regulatory requirements to this end.

Several other issues have been raised by the PFS application which I would like to bring to the Board's attention. According to the PFS proposal, rail casks will be transferred at Rowley Junction to heavy-haul trucks and then moved 24 additional miles along public roads to the proposed PFS storage facility. Rail casks may back up at Rowley Junction. This leads us to the definition of storage and storage facility; these definitions are not clear. If rail casks are sitting on a rail siding next to I-80 for several days waiting to be transferred from rail cars to a heavy haul mover, is that storage or is that transportation? Does a building with a crane that lifts casks off rail cars and onto a heavy haul truck constitute a facility that must be licensed? Does such a facility require physical protection? If PFS takes physical responsibility for shipments at the transfer station, is PFS Price-Anderson insured for this last leg of heavy-haul transport?

These issues relate to another issue posed by a private storage facility. The guarantees for states that are built into the Nuclear Waste Policy Act for a federal centralized MRS, are completely missing if the facility is private. Under the Nuclear Waste Policy Act, in which the only authorized storage facilities are federal, the State would be allowed "the right to participate in a process of consultation and cooperation...in all stages of the planning, development, modification, expansion, operation and closures of storage capacity at a site or facility within such State..." A State may voice its disapproval to Congress of a proposal to construct storage capacity of 300 metric tons or larger at any one site. In contrast, Part 72 of NRC regulations require no cooperation or involvement with the State. The State was not apprised of the proposed facility and was not even allowed to review and comment on the Emergency Plan. There was no opportunity for review or oversight, prior to NRC's acceptance of the application, except through 10 CFR Part 2.206 petitions which the NRC largely ignored. Finally, Congress authorized payments of up to $15 per kg of spent fuel or ten percent of costs associated with planning, public services and other social and economic impact costs. Instead, the State has had to spend several hundred thousand dollars of its own money. In fact, if NRC authority to license a centralized storage facility comes from the Waste Policy Act, the State would question whether the NRC has the authority under federal law to license a private spent fuel storage facility. More details are contained in the State of Utah's petition, but I would argue that the requirements for a federal or private storage facility should be consistent and suggest this to the Board as an additional recommendation.

Again, I thank you for the opportunity to appear before you today and welcome any questions you might have.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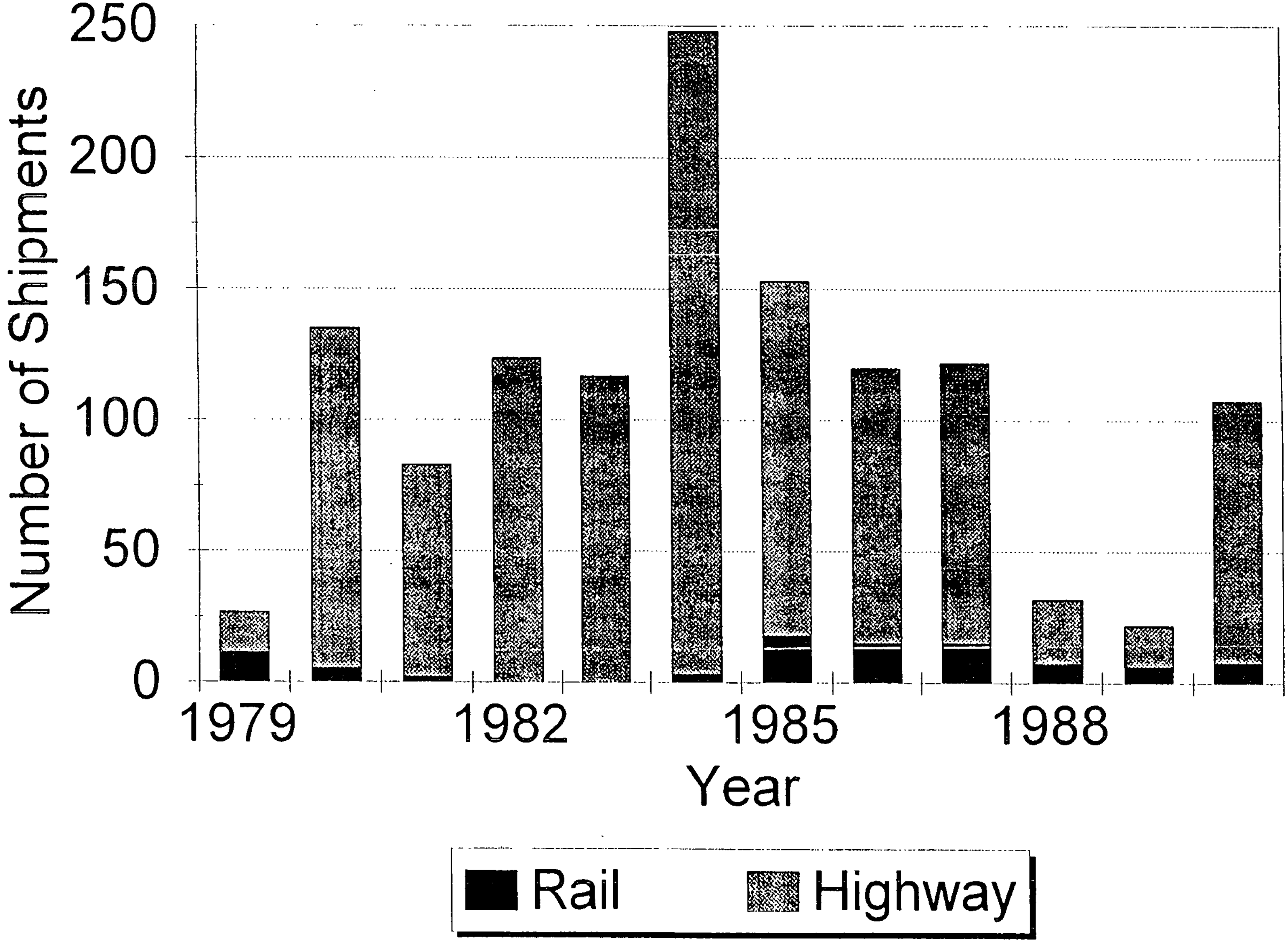
THE PUBLIC IS WORRIED ABOUT OUR PLAN TO HAUL NUCLEAR WASTE TO FARAWAY DUMPS ALONG ROUTES RUNNING DOWN MAJOR HIGHWAYS AND PASSING THROUGH HUNDREDS AND HUNDREDS OF CITIES AND TOWNS! HOW CAN WE CALM THEM DOWN?
WE'RE WORKING ON IT.
GOOD EARTH ORGANIC PRODUCE
GANDHI & CO. SOY BURGERS
PEACE BROS. TOY CO. "TRUST US WITH YOUR CHILDREN"
FRED & BENNY'S EARTH FRIENDLY
MOO BRAND MILK
100% PURE NO BGH
SOLAR INDUSTRIES, INC.

Yearly Spent Fuel Shipments



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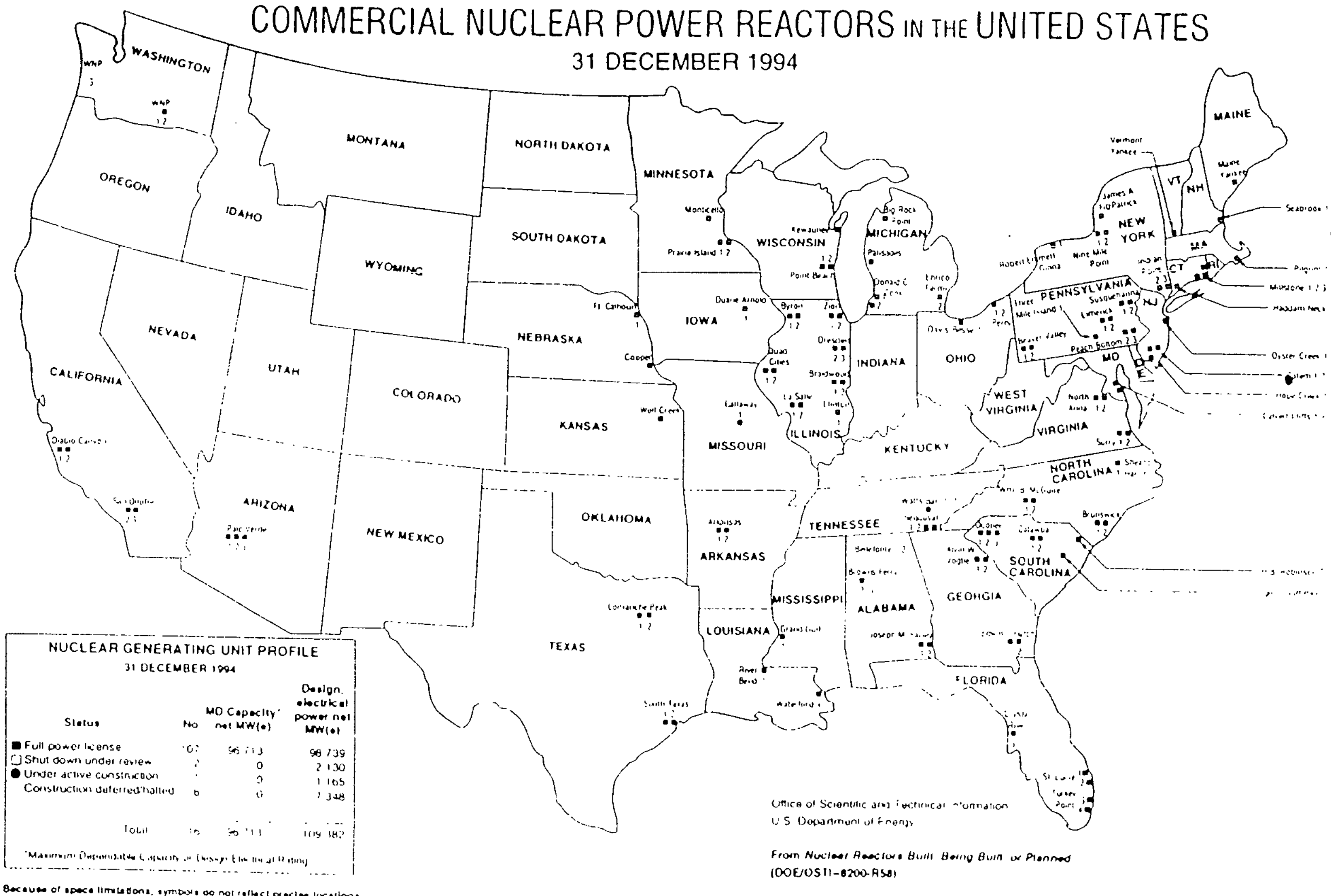


Fig. 1.1. Locations of existing and planned commercial reactors as of December 31, 1994. *Courtesy of U.S. Department of Energy Office of Scientific and Technical Information, Oak Ridge, Tennessee.*

NRC EIS On Transportation

- Degradation of fuel cladding
- Location of severe accidents
- Impact analysis
- Fire temperature
- Accident rates
- Human error
- Cask capacity
- Sabotage
- Cask burial
- Sensitivity analysis

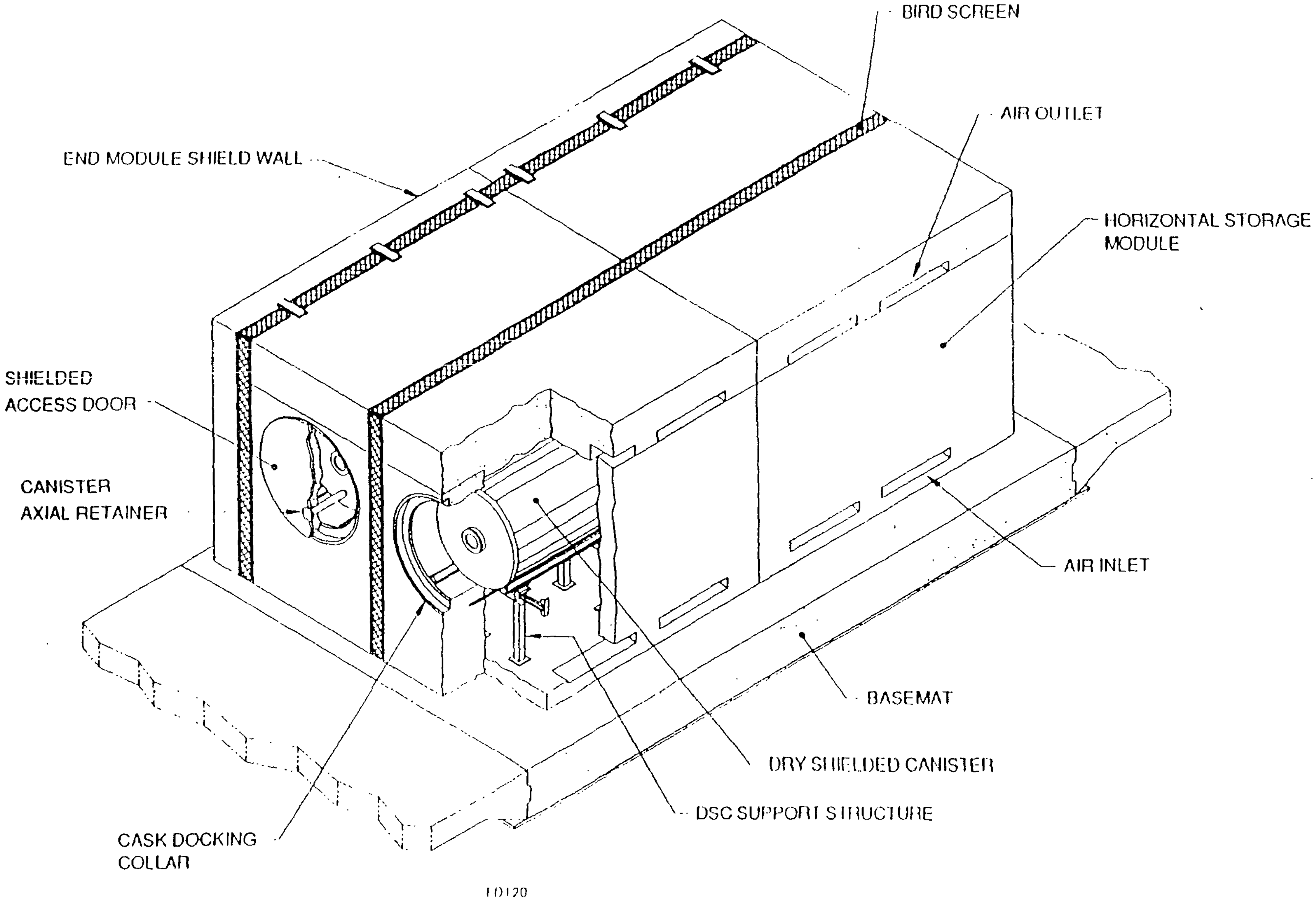
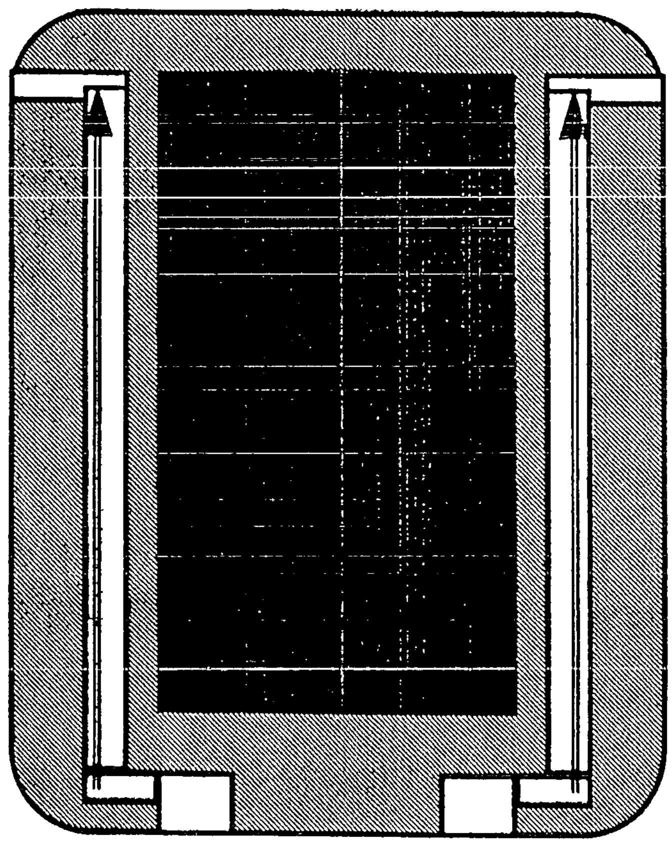
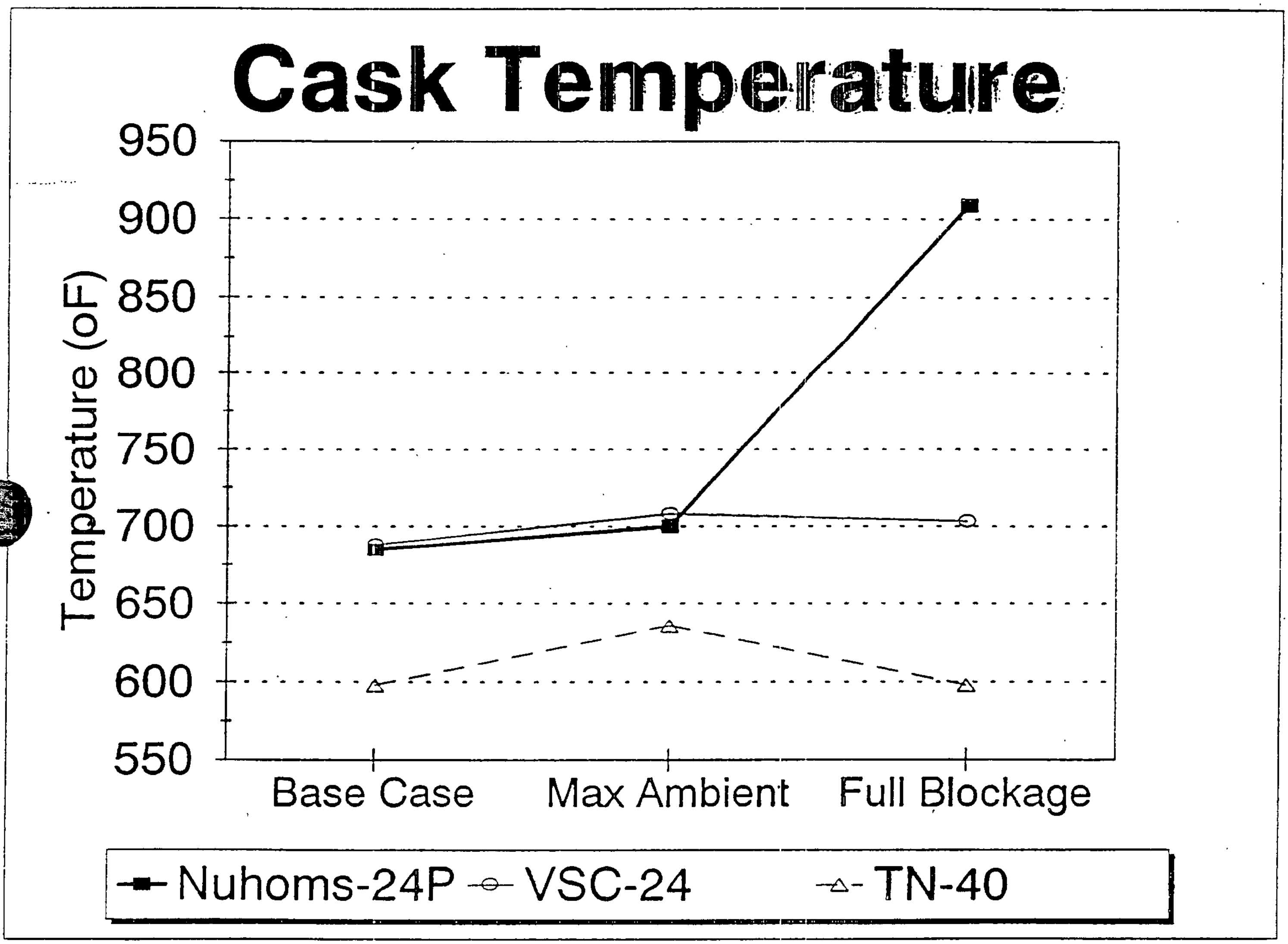


Figure 1.3-2

NUHOMS® Horizontal Storage Module Arrangement

VSC-24 Air Flow





Cask Temperature
950
900
850
800
750
700
650
600
550
Temperature (oF)
Base Case
Max Ambient
Full Blockage
Nuhoms-24P
VSC-24
TN-40

Fuel Storage and Transportation Impacts

Impact of dry cask storage and high burnup fuel were never anticipated by NUREG-0170

- Embrittlement
- Creep corrosion cracking

Creep Corrosion Cracking

- Extended storage at high temperature increases the likelihood of creep corrosion cracking
- Creep corrosion cracking increases the likelihood of impact and burst rupture in a severe accident

TABLE 5-3

FRACTIONAL OCCURRENCES* FOR TRUCK ACCIDENTS BY ACCIDENT SEVERITY CATEGORY AND POPULATION DENSITY ZONE

Accident Severity Category	Fractional Occurrences f	Fractional Occurrences According to Population Density Zones		
		Low	Medium	High
I	.55	.1	.1	.8
II	.36	.1	.1	.8
III	.07	.3	.4	.3
IV	.016	.3	.4	.3
V	.0028	.5	.3	.2
VI	.0011	.7	.2	.1
VII	8.5×10^{-5}	.8	.1	.1
VIII	1.5×10^{-5}	.9	.05	.05

*Overall Accident Rate (Ref. 5-5) = 1.06×10^{-6} accidents/kilometer
(0.46×10^{-6} accidents/kilometer for ICV's)

Table 3. Location of Severe Highway and Rail Accidents

Rail Accidents

Location	Rural	Suburban	Urban
Crestview, Florida		X	
Muldraugh, Kentucky		X	
Thermal ,California	X		
Livingston, Louisiana	X		
Baton Rouge, Louisiana			X
Denver, Colorado			X
near Pine Bluff, Arkansas		X	
Helena, Montana			X
Benson, Arizona		X	
San Bernardino, California			X
near Freeland, Michigan		X	
Laurel, Mississippi			X
Crete, Nebraska		X	
Cresent City, Illinois		X	
near Des Moines, Iowa		X	
Lewisville, Arkansas	X		
Waverly, Tennessee	X		
near Yardley, Pennsylvania*		X	
Roseville, California		X	
near Pettisville, ???			
Sound View, Connecticut	X		
Total	**6**	**10**	**5**

* Repeated in both truck and train listings

Highway Accidents

Location	Rural	Suburban	Urban
Carrsville, Virgina		X	
near Mobile, Alabama		X	
near Amsterdam, New York		X	
near Covington, Tennessee		X	
near Greenwich, Connecticut		X	
Checotah, Oklahoma		X	
Wenatchee, Washington			X
near Yardley, Pennsylvania*		X	
near Waco, Georgia	X		
Lynchburg, Virginia			X
Springfield, Massachusetts			X
Braintree, Massachusetts		X	
Sacramento, California			X
Nashville, Tennessee			X
Point Pleasant, West Virginia		X	
Brooklyn, New York			X
Oakland, California			X
Waynesville, North Carolina		X	
Sound View , Connecticut	X	X	
Total	**2**	**10**	**7**

* Repeated in both truck and train listings

Table 2. Flame Temperature Calculation

Materials Burned	Number of Accidents	Flammability Limit (% of volume)	Flame Temp (oC)*	Flame Temp (oC)**
Acetone	2	2-13	1183-3911	1472-4904
Acrylic Acid	1	3-	1198-	1404-
Acrylonitrile	1	3-16	1591-5096	1919-6457
Butyl Acrylate	1	2-10	1537-3776	1808-4753
Carbolic Acid	1	1.8-	1584-	1868-
Carbon Tetrachloride	1			
Chlorine	2			
Diesel Fuel		——		949-1004*
Gasoline (Octane)	6	1.4-7.6	2046-4884	2416-6221
Hydrogen Peroxide	1			
Isopropyl Alcohol	1	2-13	1161-4025	1323-5032
Liquified Petroleum Gas (LPG)-mostly C3H8	2	2.1-	1218-	1415-
Liquified Petroleum	2		——	
Methyl Alcohol	1	6-36	1107-3505	1392-4403
Petroleum Naptha	1		1-6	
Propane	2	2-10	1228-3586	1427-4422
Sodium Nitrate	1			
Styrene Monomer	2	1-6	1386-4434	1619-5623
Synthetic Plastic (Polymethylene polyphylisocyanate)	1			
Toluene Diisocyanate	1	1-10	998-4316	1161-6840
Trimethylchlorosilane	1		——	
Vinyl Chloride	3	3-33		1400-6172
Vinyl Chloride Monomer	1			

*Flame temperature with the heat capacity at 727 oC.
**Flame temperature with the heat capacity at 25 oC.

Note: All heat of combustion come from the "Handbook of Chemistry and Physics" except Acetone, Methanol, Propane, LPG, Acrylic acid, Butyl Acrylate and Vinyl Cloride. Acetone, Methanol, propane and LPG come from "The SFPE Handbook of Fire Protection Engineering". Acrylic Acid, Butyl Acrylate and Vinyl Chloride come from "Physical & Thermodynamic Properties of Pure Chemicals" by T.E. Daubert and R.R. Danner.

Table 11. Terminal Velocities: Truck Falls from Bridges

ID Number	Accidents with Fall	Horizontal Velocity (Vx) (mph)	Vertical Velocity (Vy) (mph)	Absolute Velocity (V) (mph)
NTSB-RAR-86-01	Collapse of the US 43 Chickasawbogue Bridge	40	*	
NTSB-HAR-88-02	Collapse of the New York Thruway Bridge over	45	48.9	66.5
	Walnut Creek in Chatauqua County	45	54.7	70.8
NTSB-HAR-90-01	Collapse of the Northbound US Rte 51 Bridge	50	*	50.0
NTSB-HAR-84-03	Collapse of Interstate Route 9 Highway Bridge	50	45.8	67.8
NTSB-HAR-74-2	Crash off the Silliman Evans Bridge, I-24/65	30	44.1	53.3
NTSB-SS-H-2	Collapse of US 35 Highway Bridge	40	*	40.0

* Bridge heights were not specified.

$V = \sqrt{(V_x)^2 + (V_y)^2}$