

5. TRANSPORT

Radioactive waste packaging (Berlin 1989)

The fundamental principle governing the extent of packaging is that the constraints in the regulations are intended to be commensurate with the hazards of the type of radioactive material, its quantity, and form. Thus, for certain waste materials that are unregulated for purpose of transportation, no packaging is required; however, at the other extreme, high-integrity containers (HIC), capable of withstanding severe accident conditions without loss of package integrity or spillage of material, are required for other types of radioactive wastes. Before proceeding, the concept of "packaging" and "package," as defined in the DOT and NRC regulations needs to be clarified. A package consists of the packaging with its content of radioactive material. Packaging is the assembly of components necessary to ensure compliance with the packaging requirements of the regulations. Depending on the type of contents, its activity level, and thermal and radioactive emissions, this assembly may include absorbent materials, radiation shielding, insulation and cooling devices, structural members to provide support and absorb shock, and the tie-down system to the vehicle. There may also be an inner and outer receptacle. Packages are designated as Type A package, Type B package, or a package for low specific activity (LSA) material.

Regulations

Generally, the regulations require that each package used for shipment of radioactive materials must be designed so that the package can be easily handled and properly secured in a conveyance during transport, has a means for manual handling if the gross package weight is between 22 and 110 lb, and has lifting attachments on the package that do not impose unsafe stresses on the package structure and where failure of the lifting device shall not affect packing integrity. Lifting fixtures must be removed during transit or designed with a strength equivalent to that required for the lifting attachments. In addition, the external surface, as far as practical, must be easily decontaminatable. The outer layer packaging must avoid, as far as practical, pockets or crevices in which water might collect. Each feature that is added to the package at the time of transport, and that is not part of the package, must not reduce the safety of the package. Packages containing LSA radioactive materials and transported as exclusive use are exempted from specification packaging, marking, and labelling.

LLW packaging

Because of the range of waste types and characteristics that is classified under the generic name LLW, the type of package

required for the material can include a wide spectrum of package configurations encompassing "strong tight packages" for LSA waste (the bulk of the LLW shipped), Type A packages, and Type B packages including those containing "highway route controlled quantities." The LSA classification applies to transported materials that are considered to be of low risk or "inherently safe," and thus require less stringent packaging and shipping requirements. LSA materials include solid waste from the fuel cycle, industrial, and institutional sources, tritiated water in concentrations not exceeding 5 mCi/ml, objects with surface contamination not exceeding 100 nCi/cm² over an area of 1 m², and inherently low-activity materials such as uranium and thorium ores. LSA material shipped as "exclusive use" (full load in vehicle) requires only strong tight packages. This provides the shipper the freedom to choose between a variety of different types of packages including plywood boxes, steel boxes, steel drums, concrete containers, and bins. Primarily because of economic considerations, those packages that are costly are frequently designed to be reusable and may contain inner containers) such as liners or drums that are removed from the outer shipping container at the burial site. The next step up in container integrity for LLW packaging is the Type A package.

Type A packages can contain waste with two upper limits for activity content of radionuclides, "A1" "A2." A1 is the activity limit for "special form" material that would be essentially non dispersible if released from a package. A2 is the activity limit for "normal form" that is dispersible (i.e., gas, liquid, or powder). Type A packages must achieve specific radiation, containment, and shielding limits under normal conditions of transport. Type A wastes include such diverse types as dewatered filter resins, irradiated hardware, and highly contaminated clothing. Type A packaging includes a range of drum, box, or cask sizes with the DOT Spec. 17C 55-gal steel drum (F-3) being a versatile "workhorse" for containing this type of material. The cask is a steel cylinder with lead y shielding in the cask wall.

Type A package is designed to maintain its integrity under "normal conditions of transport." The Type A package holds Type A quantities of material. These packages are selected by the shipper without specific regulatory approval. A Type B package is designed to maintain its integrity under both "normal conditions of transport" and hypothetical accident test conditions. The Type B package is able to hold greater quantities of radioactive materials than the Type A package. Some Type B package quantities are referred to as "highway route controlled." The packages are typically used for spent fuel and high-activity LLW.

Type B packages must be certified by the NRC under the provisions of 10 CFR 71 and, in order to be certified, must withstand the aforementioned accident test conditions. These test conditions are, sequentially, a 30-ft free drop onto an unyielding surface, a puncture test requiring a free drop greater than 40 in. onto a 6-in.-diameter steel pin, exposure to a temperature of 1475 F (800 C) for at least 30 min and immersion in water for an 8-h

period at a depth of 15 ft (5 m). If the package is designed to carry fissile materials such as enriched uranium, plutonium, or 233-U, resistance to in-leakage of water at a depth of 3 ft must be demonstrated for a period of 8 h.

The Type B package can be used to transport high activity LLW, up to 3000 times A1 quantities, 3000 times A2 quantities, or a maximum of 30000 Ci of activity. Other Type B packages designed specifically to transport radioactive waste include steel boxes with lead shielding such as the CNS 15-160B transport cask (F 5.4) which holds 15-55-gal drums or 2-80 ft³ disposable liners. A popular design cylindrical cask is the Vandenberg cask which is capable of holding 3-55-gal drums of 1-60 ft³ disposable liner. In addition to transport containers, a class of on site storage container has been developed for use at nuclear facilities. The on-site storage container (OSSC) manufactured by ATCOR Engineering Systems, Inc. is used for a storage shield in which HICs or carbon steel solidification liners are placed. The shielding provided by an OSSC can allow the processing and temporary storage of higher activity Class B and C resins, sludges, or filters. The use of the OSSC avoids the cost of shipping cask demurrage and allows a package waste volume to be maximized over an extended period.

The DOT methodology for the classification of radioactive material packages is based on the potential inhalation dose to the public resulting from an accident that assumes a small portion of the package contents, 0.1%, is released. Since the inhalation dose is radionuclide specific, the DOT has assigned dose-related values to some 150 radionuclides. These values (49 CFR 173.433 and 49 CFR 173.435), defined as A1 and A2 values, are used not only to limit the activity content in Type A packages, but also to derive specific activity limits for LSA materials, and for exempted limited-quantity packages using fractions of these values. Activities in packages exceeding the A1 or A2 values are Type B quantities requiring Type B packaging.

Spent fuel packaging (Berlin 1989)

Type B packaging, commonly referred to as a shipping cask, is used to transport the limited amount of spent fuel shipped in the United States. Because of the low utilization factor, and high expense in developing and certifying these casks, there are not many of these casks available. These casks (IF-300) generally have common features (F 5.5). They are classified by size as for either truck or rail, are reusable, have a cylindrical vessel, are equipped with impact limiters to alleviate impacts from collisions, contain two layers of radiation shielding in the walls (one for gamma radiation and one for neutron radiation), contain features to dissipate decay heat from the fuel assemblies, and are designed to contain the fuel under any accident scenario. Truck casks fall into two sizes: legal-weight truck (LWT) casks weighing about 25 tons when loaded with either one PWR or two BWR fuel assemblies, and overweight (OWT) casks that weigh about 40 tons when loaded. Rail casks can also be subclassified by weight, with the lighter rail

casks weighing about 75 tons loaded with 7 PWR or 18 BWR fuel assemblies, and the heavier cask of 100 tons holding about 12 PWR or 32 BWR assemblies. As a result of the growing shortage of spent fuel storage space at many nuclear power plants, a concept that is gaining increasing attention is the use of a cask that can provide dual short-term storage and eventual transport capability. With this in mind, there are several casks under development for spent fuel storage with features that permit their use for transport at a later date. These casks generally provide large capacities, with enhanced shielding and heat rejection capabilities.

High-integrity containers (Berlin 1989)

The high-integrity container (HIC), as its name would imply, is a high-strength package that is designed to resist crushing from static loads and corrosion from the contained waste and the soil media. The HIC, whose concept grows out of 10 CFR 61 requirements for land burial facilities, supports the disposal unit cover and thus minimizes creation of voids in the cell with resultant subsidence and infiltration. The use of the HIC eliminates the need for addition of solidification agents or adsorbents to immobilize the waste in the container. The use of HICs is growing, particularly for ion-exchange resins and filter media, and as liners used in conjunction with an outer container. In anticipation of future shipments of HLW and TRU waste, transportation systems for these waste forms are under development. Two concepts are the Defense High-Level Waste (DHLW) cask and the Transuranic Package Transporter (TRUPACT F 5.30). The DHLW is designed to carry 5000 lb by truck and incorporate the necessary shielding, impact limiters, and thermal shielding to handle normal transport or accident conditions without loss of integrity. The TRUPACT is a bimodal system that can hold 36-55-gallon drums of TRU waste.

The general criteria of the State of South Carolina for high-integrity containers to be used for high concentration waste forms are :

The container must be capable of maintaining its contents until the radionuclides have decayed, approximately 300 y, since two of the major isotopes of concern in this respect are strontium-90 and cesium-137 with half-lives of 28 and 30 y, respectively. The structural characteristics of the container with its contents must be adequate to withstand all the pressure and stresses it will encounter during all handling, lifting, loading, off loading, backfilling, and burial. The container must not be susceptible to chemical, galvanic, or other reactions from its contents or from the burial environment. The container must not deteriorate when subjected to the elevated temperatures of the waste streams themselves, from processing materials inside the container, or during storage, transportation, and burial. The container must not be degraded or its characteristics diminished by radiation emitted from its contents, the burial trench, or the sun during storage. All lids, caps, fittings, and closures must be of equivalent materials and constructed to meet all of the above requirements and

must be completely sealed to prevent any loss of the container contents.

Transportation of radioactive waste (NPWT 1978)

Reliance on nuclear power reactors has caused an enormous increase in the production of radioactive waste material. More stringent effluent standards and increased control within the reactor has produced more varieties of waste. Older plants are expected to have more leaks in equipment such as steam generators, component cooling equipment and valves, and these and many other sources increase the quantity of radioactivity dispersed throughout the waste materials. The specific activity of the waste material coming out of a reactor is not uniform. About 90 % of the volume of waste material has only 10 % of the activity. And conversely about 10 % of the volume has 90 % of the activity. This leads to several concepts in waste volume reduction of the 90 % of the volume with 10 % of the activity. Obviously, volume reduction would reduce the burden on disposal sites and reduce transportation costs. Waste disposal facility fees are based not only on volume, but also on total activity. Because of the special precautions required for handling waste of relatively high specific activity an optimization of volume and radiation level may be very economical. U.S. and international regulations require this industry to solidify and immobilize certain kinds of liquid waste materials which have in the past been dewatered or packaged. Fuel and control rod guides, fuel and control rod channels, control rod blades, defective steam generator tubes, and in-core instrumentation conduits are examples of irradiated materials which have high radioactivity content and thus have high radiation levels. These waste materials are nonstandard and are best evaluated and handled on a case-by-case basis. However, as before, efforts to increase the ease of handling these types of devices at the disposal facility will most likely result in a cost reduction for their disposal. Consultation with the disposal facility operator concerning available shielding and special operating license limitations can lead to a much smoother and less costly transfer of material.

Transportation by road

Radioactive waste is usually transported in the U.S. by truck but the economic requirements of the future could lead to heavier and larger casks. Therefore, in the future, rail may become a competitive method of transportation. However, because of present conditions and because technology for these methods of transport are similar, only trucks will be considered. In considering the limiting conditions in transporting materials, the first criteria is the size of a standard over-the-road trailer, 8 by 40 ft (2.4 x 12 m). A standard flatbed trailer is about 4 ft (1.2 m) high and has a maximum overall payload height limitation of 13.5 ft (4 m). A tractor trailer combination, i.e., a standard single trailer, double axle vehicle, has a length of 55 ft (16.8 m). The design

engineer or operator should consider adding enough space on both sides of the trailer loading bay to allow easy operation. For example, with an 8 ft (2.4 m) trailer one should have a minimum bay width of 12 ft (3.7 m) allowing sufficient space on each side of the trailer, with enough clearance and good visibility to back the trailer into position. Even with adequate side clearance, maneuvering room directly in front of the loading bay area, the so-called "backing distance" must be considered. As a rule an ideal distance is twice the length of the rig or more. Another subject of significance deals with transportation weight limitations. Obviously crane systems should be capable of handling the largest available shield combination. A gross maximum vehicle weight of 70 000 pounds (32 000 kg) is the limit in most states at this time. State laws may allow some variation but the maximum on any particular standard transportation combination is 73 280 pounds (33 240 kg). A useful rule-of-thumb for safely loading a truck allows no more than about 45 000 pounds (20 000 kg), or still better, 42 000 pounds (19 000 kg). Differences in truck weights, trailer weights and shield weights tend to make the payload vary within this range. The Departments of Highway of various States regulate overweight shipments. Laws vary from State to State but they may include restrictions on weekend, holiday, night travel, and road conditions. Certain states such as Ohio will, upon special request and presentation of need, issue a night travel permit for a particular overweight shipment. Permits for overweight can only be used on a one-time basis on the dates marked and do not transfer from one shipment to another. Permits must be in the driver's possession and are checked on a regular basis. Besides some of the special restrictions mentioned above, certain northern States incorporate frost laws in their overweight requirements. During thaws in the early spring, roadbeds may get soft and overweight trucks can easily destroy these roads. Overweight permits are not issued in these States during this short period of time, or trucks are routed along roads which have been fortified to handle such overweight traffic. Standard procedures in certain overweight categories include restrictions on travel on certain bridges, tunnels, and secondary roads. Again, these are controlled by the individual states which issue the permit.

The States are generally reluctant to issue permits for overweight loads. For example, if the load can be readily separated into two parts, a permit is not granted. States seldom grant permits for overweight loads on a routine basis. Overweight loads should generally not be considered for standard radwaste transportation except in extreme cases. Vehicles which carry radioactive material may be classified as either a sole-use vehicle or as a common carrier. A common carrier transports a group of freight referred to as general commodities. For example, radiopharmaceuticals are shipped via common carrier. Regulations on radiation and contamination levels dealing with common carriers severely limit transportation of radioactive waste. Sole-use vehicles, however, are specialized and carry, for example, only radioactive materials. They are governed by regulations which allow

higher radiation levels on cargo, higher contamination levels on package and vehicle, and larger quantities of radioactive materials. Therefore, vehicles transporting radwaste should be sole-use vehicles.

Transport modes

Radioactive waste packages can be, by law, transported by air, truck (F 5-26, F 5-27), rail, and water (barge). Neither air nor water transport is used with any frequency in the United States; the large majority of the waste is shipped by either truck or rail, with truck transport being the predominant mode.

Truck

Truck transport of radioactive waste is a specialized business conducted by a few companies. For gross vehicle weights of less than 36 Mg (80,000 lb), truck shipments are categorized as legal weight trucks (LWT), and the vehicle is permitted to use major highways. When the gross vehicle weight exceeds 48 Mg (80,000 lb), the trucks operate in an overweight (OWT) mode that requires a special permit in each state that is traversed, and generally involves restrictions on hours of travel. OWT loads exceeding 105,000 lb are not widely used because of additional restrictions imposed over this weight and the need for specialized equipment.

Table 34 U.S. Spent fuel truck shipping casks

Cask	EW-t	LW-t	C-PWR	C-BWR	L	TM
NLI-1/2	22	23	1	2	LWR	LWT
TN-8	37	39	3	7	LWR	OWT
NAC-1	24	25	1	2	LWR	LWT
FSV-1	22-3	23.5	1	3	HTGR	LWT

Rail

In the case of rail shipments, when the weight of the car and contents is below 119 Mg (263,000 lb) and certain size constraints are met, the shipment can be made in an "unrestricted interchange mode" in which standard rolling stock may be employed and there are no special operating limitations. When this weight or the size envelope is exceeded, specialized rail cars are required, and the available track may be restricted. During the major part of the last 40 y, the rail roads in the United States did not encourage routine shipments of radioactive waste. Requirements such as limited speeds that increased trip times, and booking of cars adjacent to the ones carrying the waste made an already costly transport mode prohibitive in many cases. It is only in recent

years that the railroads have begun to relax some of their restrictive requirements in an effort to encourage more use of the rails by waste shippers. Another constraint that limits rail use is that not all waste generating facilities have a rail spur on or adjacent to their property. If intermodal truck and rail shipment is then required, the economics of the situation would tend to favour using just truck shipment.

Table 35 U.S. Spent fuel rail shipping casks

Cask	EW-t	LW-t	C-PWR	C-BWR	L	TM
IF-300	63-5	68-70	7	18	LWR	OWT
NLI-10	90	97.5	10	24	LWR	rail

EW = Empty Weight, LW = Loaded weight, C = Capacity (intact assemblies) L = Licensed use, TM = Transport mode.

Transport routes

Truck transport of radioactive waste has been a controversial issue in a number of localities during the 1980s. State and local governments have attempted to prevent transport of waste from power plants or other nuclear facilities because the transport would be through populated areas. One prominent example of this is the attempt on the part of the City of New York to prevent waste shipment from the Brookhaven National Laboratory on Long Island from passing through the Borough of Queens en route to a disposal site. A judicial decision in 1986 has confirmed the authority of the federal government to regulate radioactive waste shipments. In part as a result of this controversy, and consistent with the desire to minimize the possibility of accident or sabotage, and the potential population exposure under either normal or accident conditions, the NRC and DOT have established selected preferred routes for waste transport that, for the most part, avoid urban areas and use the federal interstate highway system. These routes are pre-inspected to ensure that they are safe. It is also required (10 CFR 73) that advance notification be given to the NRC and the states traversed prior to the proposed shipment of radioactive waste. This notification must include the type and quantity of waste to be shipped, the name of the shipper and carrier, the points of origin and destination, the proposed route, and the anticipated shipping schedule. The NRC will then assess the suitability of the proposed shipping route and possibly assign compliance personnel to monitor the shipment.

Transport procedures (Berlin 1989)

The process of transporting waste packages by truck to a disposal facility, which is the most common mode of waste shipment, begins with an inspection of the truck on site after arrival to ensure that it is roadworthy and is capable of transporting the

consigned load safely. In addition, the empty truck is surveyed for residual contamination prior to loading and the levels recorded. All radwaste package loading operations are performed under the direction of the Radiation Safety Officer (or equivalent), and are monitored to ensure that the prescribed radiation limits are not exceeded and that radiation protection measures are observed when loading the truck. The packages are loaded onto the truck with the heavier ones (typically drums) placed on the bottom, plywood placed over the bottom layer, and the additional packages placed on the plywood. Once the loading is complete, the packages are blocked and braced to prevent the load from shifting during transport. A photographic record is then generally made of the truck interior showing location and bracing of the packages. The truck door is then closed, latched, and the shipper's seal is applied. The seal number is recorded. Although not quite identical, a similar approach is used to load waste packages onto rail cars.

The truck driver is provided specific instructions to cover the transport of the packages including the maintenance of exclusive use shipment controls (if relevant) and emergency procedures and instructions defining response to accidents while carrying the waste packages. It should be noted that the primary responsibilities for ensuring that radioactive waste is safely transported belong to the shipper and carrier. However, if an accident occurs, the state or local governments in whose jurisdiction the accident occurred assume the lead responsibility for protecting people in the vicinity of the accident from overexposure, appointing an emergency response team, and coordinating communication between the various agencies responding to the accident. The federal agencies will provide support as requested to state and local agencies. The driver, after receiving the transport instructions and emergency procedures, confirms in writing his (her) understanding and acceptance of the procedures.

Transport responsibilities

The vehicle is placarded with the diamond shaped "Radioactive" placard for exclusive use shipments of LSA material, or for any shipment containing packages bearing the "Radioactive-Yellow III labels (200 mrem/h dose limit on package surface). The placards are attached to the front, back, and both sides of the vehicle. The specific hazardous material identification number must also be displayed in proximity to each of the placards. After loading of the vehicle is complete, it is surveyed on all four sides and the truck cab for radiation levels. The radiation levels are recorded on a plot sketch of the truck.

Individual commercial burial facilities and the host states may also impose their own additional requirements on the shipment. For example, the State of Nevada requires that shippers of waste to the Beatty disposal facility complete a "Low-Level Radioactive Waste Shipment Compliance Certification" warranting that the waste shipment was inspected within at least 48 h prior to shipment and conforms in all respects to federal and state requirements for

shipment, transportation, and disposal. In addition, the state requires certification by the shipper that the sections of the U.S. Ecology Site Operations Manual dealing with radioactive material possession limits and receipt requirements have been read and adhered to. These certifications are provided by the shipper in conjunction with a valid users permit for shipments to the state, an overweight permit (if required), an inspection report showing compliance with all regulatory requirements, the bill of lading, and the manifest. For shipments of certain types of radioactive waste such as spent fuel, federal regulations (10 CFR 73) require that the shipment be provided with additional security protection against the possibilities of theft or sabotage. This security protection includes the use of drivers and guards with special training, control of the transport route, establishment and use of a rapid communication network, and transport equipment that can be immobilized and that also provides protection against attack.

Shipper requirements and constraints (Berlin 1989)

The shipper bears the major responsibility for ensuring the adequacy of the waste packaging, that the carrier is licensed and follows proper procedures, and that the burial site operator is certified to receive the packages. The mechanism for confirming that these responsibilities are being met is the shipping paper or "Radioactive Waste Manifest" that accompanies each shipment of waste. The manifest contains the following information as a minimum: DOT proper shipping name and identification number for the material (49 CFR 172.101); NRC Certificate Identification, if relevant; Shippers certification that the waste package has been properly prepared for transport; Description of the chemical and/or physical form of the waste; Name of each radionuclide and the activity of the radioactive material in each package(s); Type of packaging and transport index assigned to each package; Category of label applied to each package; and Waste form and classification (10 CFR 61). Prior to loading the packages on the transport vehicle, the shipper must affix warning labels on two opposite sides of the package. There are 3 different warning labels, distinguished as "Radioactive-White I, Radioactive-Yellow II, and Radioactive-Yellow III," that indicate the external radiation level and imply specific handling procedures. The maximum permissible dose rate at any point on the external surface of any package of radioactive materials may not exceed 200 mrem/h (by regulation) or 10 mrem/h at 1 m from the surface. If the waste packages are to be shipped by "exclusive use" vehicle, higher radiation levels are permitted: 1 rem/h at the package surface for a closed transport vehicle, 200 mrem/h at the external surface of the vehicle, 10 mrem/h at 2 m from any lateral external surface of the vehicle, and 2 mrem/h in any position of the vehicle that is occupied by a person (transport worker).

In addition to the warning label, the shipper must mark each package with the applicable DOT package specification, proper shipping name (from 49 CFR 172.101 list of hazardous materials),

and identification number, the appropriate package Type (A or B), and the gross weight (if greater than 110 lb). In order to ensure compliance with the waste classification requirements of 10 CFR 61, the NRC has developed a position (1983) that requires that its licensee, prior to packaging of LLW for shipment, must make a reasonable effort to ensure a realistic representation of the distribution of radionuclides within the waste, must classify the waste in a consistent manner, establish an on site compliance program specific to that facility that considers the different radiological and other characteristics of the different waste streams generated by the facility, and adhere to an objective of achieving measured or inferred radionuclide concentrations accurate to within a factor of 10. Licensees may use at least four basic methods either individually or in combination to characterize packaged wastes; materials accountability, classification by source, the conversion factor technique using a calibration curve, or a direct measurement of individual radionuclides. For the conversion factor technique, which is used by many industrial and fuel cycle facilities, external gross gamma radiation readings are converted to an estimated curie content of the package using a calibration curve specific to the type of material in the package.

Inspection

The typical procedure at the shipper's facility for loading of the waste in drums (the most common form of packaging for LLW) is to :

1. Inspect each drum prior to use for obvious defects (e.g., hole, split seam).
2. Place drums on pallets at the drumming station and load with waste material. All liquid wastes are immobilized prior to closure of the drum.
3. Place the lid with the gasket on the drum. Ensure that there is a good fit between drum and lid.
4. Attach the bolt ring to the drum. The bolt ring must engage both the lid and rim of the drums. Screw in bolts, attach nuts, and screw on tight.
5. Reinspect the drum for any defects.
6. Affix appropriate marking/label to the drum.
7. Weigh the drum and record the weight on the label affixed to the drum. Also record assigned "container number" on drum.
8. Perform a radiation and contamination survey of the external surface of the drum to validate that the radiation level on the external surface does not exceed 200 mrem/h and that the level of removable radioactive contamination is kept ALARA. The results of the surveys are to be recorded and kept on file. If ALARA levels are not achieved, decontaminate the external surface and repeat the survey.
9. Determine the activity level of the drum (presumes use of the conversion factor technique).
10. Using a fork lift, move the pallet with the drum on it to the temporary storage area and record the location of the drum.

Loading and unloading (NPWT 1978)

Heavy duty cranes capable of lifting 25 tons (22 700 kg) would be desirable for handling most radwaste shipping shields in use today. Since they allow greater efficiency in moving the radwaste containers within the reactor facility. Particular consideration should be given to designing material handling devices which are compatible with both the reactor requirements and a waste hauling contractor's requirements at the disposal facility. Direct communications between the designer and/or operator at the reactor, and personnel at the various waste disposal facilities are desirable.

Safety restrictions

Safety restrictions are placed on truck drivers as agents of their employer to ensure that loads of hazardous materials are properly transported. The driver is required to ensure that he has adequately secured the load by tie-downs. Although the transportation shield must include safety features in its construction, it is the responsibility of the driver to assure that the shield is secured in the fashion for which it was designed. The other major safety regulation which affects timely transport of radioactive wastes between facilities is the limitation on driving times. Single drivers can drive a maximum of 10 hours per day and 60 hours per week at which time he must take as a minimum, a specified length break before he resumes driving. This dead-time must be taken into consideration when scheduling unusual situations which may require many loads since this dead time affects turnaround time. This problem can be alleviated by adding a second driver. This allows a small decrease in net turn-around time by reducing the time the truck is not moving.