Economics

of

10 CFR Part 61

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Abstract

The NRC staff has evaluated the economic impacts of the requirements of 10 CFR Part 61. Based on our evaluation the increase in the cost of producing nuclear power will increase by about 0.1 percent or 0.01 mills per kilowatt hour over the next twenty years. The total cost of complying with the requirements of 10 CFR Part 61 is about 4 percent of the total estimated waste disposal costs for the next twenty years. Lastly, the increase in occupation exposure is about 1 percent of the average dose received at an average Pressurized Water Reactor (PWR) power plant and 0.5 percent for an average Boiling Water Reactor (BWR) power plant.

Economics of 10 CFR Part 61

A. Background

On December 27, 1982, the NRC issued final regulations to provide specific requirements for licensing the land disposal of low-level radioactive wastes. Under 10 CFR Part 61 the regulation establishes performance objectives for the land disposal of waste; technical requirements for the siting, design, operations, and closure activities for a near-surface disposal facility; technical requirements concerning waste form, classification and manifests that waste generators must meet for the near-surface disposal of wastes; institutional requirements; financial assurance requirements; and administrative and procedural requirements for licensing a disposal facility.

The two most important areas in 10 CFR Part 61 which are applicable to waste generators involve the classification of waste and the waste form requirements. These requirements are implemented for NRC licensees through the manifest requirements in 10 CFR § 20.311.

The waste classification system establishes three categories for waste acceptable for disposal at a near-surface burial facility. This classification system is based on the concentrations of radionuclides important for disposal. Using this system, waste having greater radiologic hazards are required to be disposed of with greater protection.

The waste classification system is also the basis for determining the appropriate waste form requirements. Class A wastes must meet the minimum waste form requirements which are intended to ensure worker safety during handling and disposal operations. Class B and C wastes must meet the minimum waste form requirements and must also meet the waste stability requirements. The waste stability requirements are intended to ensure that the higher activity wastes will have long term stability and not be subject to degradation in the burial environment.

The NRC has issued a Technical Position on Waste Classification and a Technical Position on the Waste Form. These technical positions provide guidance on acceptable methods for demonstrating compliance with the waste classification and waste form requirements in 10 CFR Part 61.

This paper summarizes the major economic and occupational exposure impacts of the requirements of 10 CFR Part 61.

B. Waste Classification and Waste Form Requirements

Waste classification is a systems approach to control the potential dose to man from disposed waste and to minimize long-term institutional control requirements and costs. The components of the system include the

site characteristics, design, and operation; institutional controls; waste form; and intruder barriers. The quantity and type of radioactivity permitted in each waste class depends on the combination of the above components.

The waste classification system establishes three categories for wastes acceptable for disposal at a near-surface disposal facility: Class A, Class B, and Class C. This classification system is based on the concentrations of radionuclides important for disposal. Using this system, wastes having greater radiologic hazards are required to be disposed of with greater protection. The radionuclide concentrations for Class A, B, and C wastes are presented in 10 CFR § 61.55.

Class A wastes contain the lowest concentrations of the nuclides important for disposal and must meet only the minimum waste form requirements. Because of the lower concentrations, waste instability will not produce significant hazards to public health and safety. The minimum waste form requirements which all waste classes must meet are intended to facilitate handling at disposal sites and to protect the health and safety of workers. These minimum requirements are generally adopted from existing disposal facility license conditions and include provisions such as: liquids must be absorbed or solidified; explosives or pyrophoric materials are prohibited; and wastes must be treated to reduce biological, pathogenic, or infectious hazards.

Class B wastes have higher activities than do the Class A waste materials. Class B wastes must be segregated from Class A wastes and must meet both the minimum waste form and stability requirements (i.e., they must also be structurally stable to minimize waste degradation and the resultant subsidence of the waste trenches). Waste form stability can be obtained by processing (e.g., solidification), the use of a container or structure to provide stability (e.g., high integrity container) or by the waste itself (e.g., a large activated component). To the extent practicable, stable wastes should maintain gross physical properties and identity for 300 years.

Class C wastes have higher concentrations than do the Class B wastes. In addition to stability, Class C wastes must be disposed of with an intruder barrier to minimize the possibility of inadvertent intruders contacting the wastes following a possible breakdown in institutional control at the disposal site. Placement at the bottom of the disposal trench generally provides an acceptable intruder barrier for Class C wastes.

Wastes which have concentrations which exceed Class C limits are generally unsuitable for disposal at a near-surface disposal facility. The rule, however, allows case-by-case determinations of the acceptability for disposal for these wastes based on the proposed waste form, disposal method, and site conditions.

The waste stability requirements which Class B and C wastes must meet are intended to provide long-term structural stability of the waste under disposal conditions so that degradation of the waste does not lead to trench cover failure and water infiltration. Stability is also important in limiting potential exposures to an inadvertent intruder since it provides a recognizable and nondispersible waste form. The rule provides that a structurally stable waste form will generally maintain its physical dimensions and its form under expected disposal conditions such as the weight of overburden or compaction equipment, the presence of moisture and microbial activity, and internal factors such as radiation and chemical effects. The rule also requires minimizing liquid content and void spaces between the waste and its packaging. Class B and C liquid wastes, or wastes containing liquid, must be converted to a form that contains as little free-standing and noncorrosive liquid as is reasonably achievable. A free-standing liquid limit of 1 percent of the volume of the waste is established for wastes in a disposal container designed to ensure stability, and a limit of 0.5 percent of the volume of the waste is established for waste processed to a stable form.

C. Impacts of the Waste Classification Requirements

The Technical Position on Waste Classification presents guidance on acceptable approaches for implementing a waste classification program. The complexity of these waste classification programs will vary depending on the licensee and the nature of his waste management operations. The following describes the estimated impacts for classifying wastes at both non-fuel cycle and nuclear power plant waste generators.

1. Non-Fuel Cycle Waste Generators

Non-fuel cycle waste generators include hospitals, universities, biomedical organizations and industrial licensees. In the past these licensees have generally used the materials accountability method for determining waste nuclide concentrations. For these licensees, this method will continue to be acceptable and the only impact to their operations will be the preparation of more detailed manifest forms. This impact is not expected to result in significantly increased costs or occupational exposure.

2. Nuclear Power Plant Waste Generators

Monetary Impacts

For a nuclear power plant waste generator, the Technical Position on Waste Classification recommends that wastes be classified based on the results of a waste stream sampling and analysis program. From the sample analysis results, correlation factors between the difficult-to-measure nuclides and the more easily measured nuclides are developed. The monetary impacts to nuclear power plant licensees would include the costs of the sample measurement program, the costs of developing correlation

factors and procedures for classifying wastes, the costs of the manifest preparation, and the general administrative costs for implementation. These costs have been estimated by the staff and are listed in Table 1. Initially, waste stream sampling, analysis, and the development of scaling factors is assumed to be performed. Sample analyses are assumed to cost $2000 per sample. Level of effort costs are assumed to be $8000 per staff month. The cost of staff time to prepare waste classification procedures and for the general administration of the program and training are also included in the estimate. The total initial cost is thus assumed to be $86,000. After the initial program is established annual waste stream sampling is assumed for the verification of the correlation factors. In addition, other costs related to the general administration of the program are also assumed. Annual costs are assumed to be $38 000 per year. There should be no cost attributable to lost generating time. because modifications which may be necessary to install improved sampling capability should not require plant shutdown.

Table 1

Waste Classification Costs

Initial Costs for Waste Classification

Item	Units	Item Cost
Sampling and Development of Scaling Factors	3 staff-months	$24,000
Analysis	7 samples	14,000
Development of Procedures	3 staff-months	24,000
Implementation	3 staff-months	24,000
	Total Initial Costs	$86,000

Annual Cost for Waste Classification

Item	Units	Item Cost
Sampling and Scaling Factor Update	1 staff-month	$ 8,000
Analysis	7 samples	14,000
Administration	2 staff-months	16,000
	Total Annual Costs	$38,000

Occupational Exposure Impacts

The NRC staff has estimated that the increment in occupational exposure due to the increased handling of radwaste could range up to 5 man-rems per year. This exposure results from additional sampling and sample handling not previously required. At the Maine Yankee, Vermont Yankee, Oconee, and McGuire stations, exposures from sampling, handling and gamma spectral analysis of radwaste samples range from 20 to 500 person-mrem per sample.

This exposure compares to an average of 570 person-rem year at Pressurized Water Reactors (PWR's) in 1982 and average of 940 person-rem at Boiling Water Reactors (BWR's) in 1982. Therefore, the increase in dose due to the requirements of 10 CFR Part 61 is approximately 1 percent of the total dose received in an average PWR power plant and 0.5 percent at an average BWR power plant.

D. Impacts of the Waste Form Requirements

Prior to the implementation of 10 CFR Part 61, solidified wastes needed only to be solid, free-standing monoliths with no free liquid. The 10 CFR Part 61 requirements add new provisions that Class B and C wastes maintain their structural integrity in the burial environment. Therefore, a stable waste form must withstand the inherent mechanical loads and radiation environment and must not degrade due to the presence of moisture and microbial activity. These new provisions will necessitate that waste generators demonstrate that Class B and C wastes will maintain their structural integrity over the long term. The Technical Position on Waste Form presents a series of test methods and recommended results which may be used for demonstrating stability.

1. Non-Fuel Cycle Waste Generators

Generally, non-fuel cycle waste generators produce only Class A wastes. Therefore, the waste processing and packaging techniques used in the past will continue to be acceptable. No significant impacts are estimated to result for these licensees.

There are several non-fuel cycle waste generators which have been identified as producing Class B and C waste materials. The impacts on these waste generators are difficult to assess at this time. However, 10 CFR Part 61 allows several options for providing stability. These options provide flexibility for individual waste generators and should help in minimizing implementation costs. Therefore, the NRC staff believes that because of the relatively small volumes of Class B and C waste produced, the total cost impacts for meeting the waste stability requirements will be small.

2. Nuclear Power Plant Waste Generators

Monetary Impacts

The costs for developing and implementing the waste stability requirements will vary from facility to facility. However, many power plants utilize solidification vendor services and can use the generic test data developed by these vendors for solidification agent qualification. In addition, testing programs performed consistently with the Technical Position on Waste Form are intended to be a one-time testing program; periodic requalification of the entire testing program is not required. The NRC staff, however, would expect that a short test program would be periodically performed to verify the operability of the solidification system. This testing could be limited to compression and immersion testing on one to three formulations.

The NRC has estimated the solidification agent qualification costs based on the effort expended by Brookhaven National Laboratory (BNL) in performing the tests identified in the Technical Position on Waste Form . Table 2 shows the cost data obtained from BNL. The individual sample test costs were then doubled to account for profit, testing laboratory setup time, etc. for commerical organizations performing this testing.

Table 2

Sample Test Estimates

Basis	No. of Samples	Effort Days	Total Cost	Cost Each Sample (BNL)[a]	Cost Each Sample (Commercial Testing)[b]
Compression tests:	12	3	$1200	$100	$200
Radiation tests:	12	3	$1200	$100	$200
Leach tests:	36	6	$12000	$333	$600
Biodegradation tests	12	3	$6000	$500	$1000
Thermal cycle tests:	12	2	$4000	$333	$600

a. Based on BNL estimates and $2000/staff week
b. Based on two times the BNL costs

Tables 3 and 4 show the NRC estimates for the number of formulations which would probably be tested at a PWR plant, a BWR plant, and for a topical report.

Table 3

PWR Plant Test Formulations

PWR Waste Streams	
Boric acid evaporator bottoms 2 formulations to envelope waste chemistry	2
Resins 1 formulation for each resin type used; 2 types in plant	2
Waste evaporator bottoms 3 formulations to envelope waste chemistry	3
Total formulations to be tested	7

Table 4

BWR Plant Test Formulations

BWR Waste Streams	
Sodium sulfate evaporator bottoms 2 formulations to envelope waste chemistry	2
Resins 1 formulation per resin type; 2 resin types	2
Waste evaporator bottoms 3 formulations to envelope waste chemistry	3
Total formulations to be tested	7

Table 5

Topical Report Test Formulations

Topical Report Approach	
Boric acid evaporator bottoms	2
Sodium sulfate evaporator bottoms	2
Resins	3
Waste evaporator bottoms	3
Calciner bottoms	2
Ash	2
	Total 14 formulations

Table 6 itemizes the costs for complete testing of one formulation. Table 7 shows the costs for performing the tests for a PWR, a BWR, and a topical report.

Table 6

Costs for Complete Formulation Testing

Test	Cost	Samples	Total
Compression	$200	3	$600
Irradiation	$200	3	$600
Thermal cycling	$600	3	$1800
Biodegradation	$1000	3	$3000
Leaching (a)	$600	6	$3600
		Total	$9600

a. Immersion tests are performed in conjunction with leach tests

Table 7

Testing Costs

	Formulations	Single Formulation Cost	Total Cost
PWR	7	$10,000	$ 70,000
BWR	7	$10,000	$ 70,000
Topical	14	$10,000	$140,000
Administrative[a]			$ 20,000

a. Administrative costs which include test program planning and report preparation are estimated to cost $20,000 based on 10 staff-weeks effort at $2000/week. These costs are applicable to each approach.

It is expected that the solidification agent qualification testing will be performed on small, laboratory size samples (0.5 to 1 liter). The physical process for mixing samples will generally be different from that used for full-size waste products. The Technical Position on Waste Form, therefore, recommends that full-scale waste size tests be performed to confirm that the laboratory size specimens correlate with the waste forms produced at full-scale. The full-scale testing costs will be dependent on the size of the container used. Full-scale testing costs are estimated in Table 8.

Table 8

Full-Size Testing Cost Estimates

55-gal Drum		
Drum materials		$ 200
Compression tests (3 samples)		$ 600
Immersion tests (3 samples)[a]		$ 700
Labor		$ 500
	Total	$2000
50 ft^3 Liner		
Liner and materials		$6000
Compression tests (3 samples)		$ 600
Immersion tests (3 samples)[a]		$ 700
Labor		$1000
	Total	$8300

a. Immersion tests are assumed to be performed in demineralized water for 90 days with subsequent compression testing.

The total program costs will be the sum of the formulation testing costs, the full-size sample testing costs and the administrative costs associated with test program development and report preparation. These costs are estimated in Table 9.

Table 9

Total Program Costs

	PWR	BWR	Topical Report
Sample Testing	$70,000	$70,000	$140,000
Full Scale[a]	$ 2,000	$ 2,000	$ 8,300
Administrative	$20,000	$20,000	$ 20,000
Total	$92,000	$92,000	$170,000

a. It is assumed that individual PWR and BWR plants have systems which utilize 55-gal drum size containers. However, vendors providing mobile services generally use large liners for waste solidification. It is assumed that full-scale vendor testing for the topical report approach utilizes a 50-ft^3 liner.

The NRC staff has assumed that about one-third of the operating power plants use installed solidification systems. The remaining two-thirds utilize vendor-supplied services. The vendor-supplied services are expected to be qualified using a topical report approach. Obviously, this will result in lower unit costs for each utility utilizing such services. Similarly, if utilities share generic data applicable to their installed solidification systems, cost savings will result. In addition, many multiple unit stations utilize shared solidification systems. It is assumed, therefore, that 45 stations will utilize vendor supplied data.

Some plants, however, have solidification systems which are significantly different from those qualified by vendor supplied data. It is assumed that 10 stations will generate their own qualification data. The total qualification costs are estimated in Table 10.

Table 10

Total Cost For Solidification Agent Qualification

	Number of Stations[a]		Total Cost
Individual Station Qualification	10		$ 920,000
Qualification by Referencing Generic Data[b]	45		$ 850,000
		Total	$ 1,800,000

a. Some stations have multiple units using shared solidification systems.
b. Assumes five vendors develop generic data.

The costs for periodic verification of the solidification systems are estimated in Table 11. Verification would not need to be performed more than once a year.

Table 11

Verification Costs

3 Waste Formulations

2 Samples per Formulation for Compression Testing (Total of 6)
2 Samples per Formulation for Immersion Testing (Total of 6)

Test	Cost	Number of Samples	Total
Compression	$200	6	$1,200
Immersion	$233	6	1,400
			$2,600
1 staff-month effort			$8,000
Total Verification Costs Per Plant			$11,000

E. Total Costs

The total estimated cost of implementing 10 CFR Part 61 for nuclear power plants for a twenty year period is summarized in Table 12. Both waste classification and waste form qualification costs are included. These costs are based on the assumptions that there are seventy-five nuclear units in operation for a period of twenty years. It is also assumed th because of shared solidification systems at multiple unit plants 55 stations will upgrade their solidification agent qualification programs.

The cost for initial waste classification as estimated by the staff for either a PWR or a BWR is $86,000 and the annual classification costs are estimated to be $38,000 (Table 1). The total cost for the industry for qualification of solidification agents is estimated by the staff to be $1,800,000 (Table 10) and the annual cost for verification of solidification agents is estimated to be $11,000 (Table 11) for each station. The total estimated expenditure due to implementing 10 CFR Part 61 is $75,000,000 for a twenty year period.

Table 12

Total Costs Due to Implementation of 10 CFR Part 61

Waste Classification

Year 1: $86,000/plant (75 units) = $ 6,500,000
Years 2-20: $38,000/plant (75 units)(19 years) = $ 54,000,000

Total for Waste Classification $ 61,000,000

Waste Form

Initial qualification $ 1,800,000
Verification
$11,000 x 55 stations x 19 yrs. = $ 12,000,000

Total for Waste Form = $ 14,000,000

Total Costs in 20 yrs. Due to 10 CFR Part 61 Requirements = $75,000,000

The total estimated cost of waste disposal at a nuclear power plant is given in Table 13. The capacity of operating commercial nuclear power plants in the U.S. in 1983 was 59,000 Mwe (Reference 1). Of this capacity approximately 66 percent of the power is produced by PWR plants and 34 percent is produced by BWR plants. Total costs for waste disposal including transporation were estimated for a generic 800 Mwe PWR and 800 Mwe BWR in Reference 2. The estimated total waste disposal cost for a generic PWR plant as shown in Reference 2 is \$830,000/year and for a generic BWR plant is \$2,800,000/year. This breaks down to approximately \$1,000/Mwe for a PWR and \$3,500/Mwe for a BWR. The total cost for waste disposal in a 20 year period is estimated to be \$2,200,000,000.

Table 13

Total Waste Disposal Costs Including Transportation (20 years)

Assume a total nuclear generating capacity of 59,000 Mwe of which 66 percent of this capacity is from PWR's and 34 percent of the capacity is from BWR's.

Total Capacity: 59,000 Mwe
PWR Plant Capacity: 39,000 Mwe
BWR Plant Capacity: 20,000 Mwe

Annual Waste Disposal Cost per 800 Mwe PWR Plant:	\$830,000
Annual Waste Disposal Cost per 800 Mwe BWR Plant:	\$2,800,000
Annual Waste Disposal Cost per PWR Mwe:	\$1,000/Mwe
Annual Waste Disposal Cost per BWR Mwe:	\$3,500/Mwe

Total Waste Disposal Cost for a 20 Year Period: \$2,200,000,000

When the cost of implementing 10 CFR Part 61 is compared to the total costs for waste disposal, the costs due to 10 CFR Part 61 are approximately 4 percent of the total waste disposal costs for the next twenty years.

The total nuclear industry generating cost for the twenty year period is estimated in Table 14. The total commercial nuclear generating capacity as stated above is 59,000 Mwe. The average production cost for generating nuclear power as stated in Reference 3 is 10.67 mills per kwh. Therefore, the total estimated nuclear industry generating costs for the 20 year period is $\$7.7 \times 10^{10}$.

Table 14

Estimated Total Power Generation Costs

Assume that power is generated for a 20 year period at 70 percent availability at nuclear units having a 59,000 Mwe capacity at 10.67 mills/kwh.

Total Power Generation Cost: $\$7.7 \times 10^{10}$

A comparison of the total costs of implementing 10 CFR Part 61 and the total industry cost shows that the increase in cost is about 0.1 percent or about 0.01 mills per kwh.

Conclusion

Based on cur evaluation, the NRC staff believes that the requirements of 10 CFR Part 61 can be implemented without a major impact on costs to the nuclear power industry or major increases in occupational exposure. The increase in the cost of producing nuclear power will increase by about 0.1 percent or 0.01 mills per killowatt hour over the next twenty years. The total costs of complying with the requirements of 10 CFR Part 61 is about 4 percent of the total estimated waste disposal costs for the next twenty years. Lastly, the increase in occupational exposure due the increased waste stream sample analysis is abcut 1 percent of the average dose received at a PWR nuclear power plant and about 0.5 percent of the average dose at an average BWR power plant.

References:

1. Nuclear News, Volume 26, No. 10, August 1983, pp. 97-101.

2. G. Trigilio, "Volume Reduction Techniques in Low-Level Radioactive Waste Management," NUREG/CR-2206, Sept. 1981, Chap. 4.

3. DOE/EIA-0373/80, "Thermal-Electric Plant Construction Cost and Annual Production Expenses - 1980," June, 1983.

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

June 27, 1985

MEMO FOR: Jim McKnight, RSB

FROM: Vicki Yanez, PPMB

Vicki

SUBJECT: Transmittal of Speeches

Attached are [redacted] copies of each of the following speeches to be sent to the PDR and DCS. We have filed the NRC Form 426.

1. "Economics of 10 CFR Part 61"

2. "Development of a Training Regulation for Nuclear Power Plant Personnel"

3. "Natural Analogues and Validation of Performance Assessment Models"

4. "The Evolution of U.S. Reporting to the IAEA"