MINIMIZING COST AND RADWASTE WITH PROTECTIVE CLOTHING

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ABSTRACT

Protective Clothing plays a major role in the decommissioning and operation of nuclear facilities. Literally thousands of dress-outs occur over the life of a decommissioning project and during outages at operational plants. In order to make the optimal decision on which type of protective clothing is best suited for the decommissioning or maintenance and repair work on radioactive systems, a number of interrelating factors must be considered, including:

- Cost
- Radwaste
- Comfort
- Protection
- Personnel Contamination
- Convenience
- Logistics/Rad Material Considerations
- Reject Rate
- Durability
- Security
- Personnel Safety
- Gloves and Booties

This paper discusses these factors and should help individuals making decisions about protective clothing as it applies to their application.

INTRODUCTION

Over the last several years there has been a trend of nuclear power plants either running trials or switching to Single Use Protective Clothing (SUPC) from traditional laundered protective clothing. In some cases, after trial usage of SUPC, plants have chosen not to switch. In other cases after switching to SUPC for a period of time, some plants have chosen to switch back to laundering. Based on these observations, this paper reviews the “real” drivers and issues regarding the selection and use of protective clothing in the nuclear industry.

Survey of Single Use Protective Clothing Users at Commercial Operating Plants

To better understand the drivers for why some plants were considering switching, a survey of 30 users of Single Use Protective Clothing was conducted. Telephone interviews were conducted over a 4-month period. A survey form was used to ensure consistency and quality. Questions were asked in 10 topical areas. Key survey areas included:

- Drivers for Switching
- Performance Analysis
- Economics (Costs)
- Experience/Results

It was determined through the survey that there is no “Bill of Rights” for garments. Clearly, not all garments are created equal. Different plants have different drivers for switching to SUPC. Personnel Contamination (PC) events were reported to be one of the drivers for switching to SUPC. However, it should be noted that there are numerous variables when recording, evaluating, and analyzing PCE’s. Outage scope, outage length, system and area contamination levels make PCE trending from one outage to the next extremely difficult. Typically, when some improvement of PC events was noted, the switch was made, numerous other changes occurred. This made it very difficult to isolate what caused improvements. We also discovered that no plant surveyed could produce a cost study showing SUPC to be less expensive. The only cost analysis provided concluded laundering is less expensive. Also it is noteworthy that one major user of SUPC switched back to laundering because the additional costs were not justifiable. Based on the survey, it can be concluded that plants considering switching should perform an in-depth and rigorous cost analysis.

LEVEL OF SUPC USAGE BY PLANTS SURVEYED

The table below summarizes the level of usage by the 23 plants surveyed.

Table I. Summary of SUPC Usage – 23 Plants Surveyed

SUPC Usage	Plants
No Trial – Benefit Not Evident	2
Trial – Did Not Prefer	2
Trial – Considering But Undecided	2
Gloves Only	1
Modesties Only	2
Outage Only	1
PC’s Only – Laundering Booties/Gloves	9
Full SUPC	3
Largest Fleet Selected Laundering After Trial	17

Decision Tree

Based on the survey results, it was determined that there are many interrelating factors to be considered. Figure 1, Decision Tree, depicts the key factors that need to be considered. Each factor will be discussed.

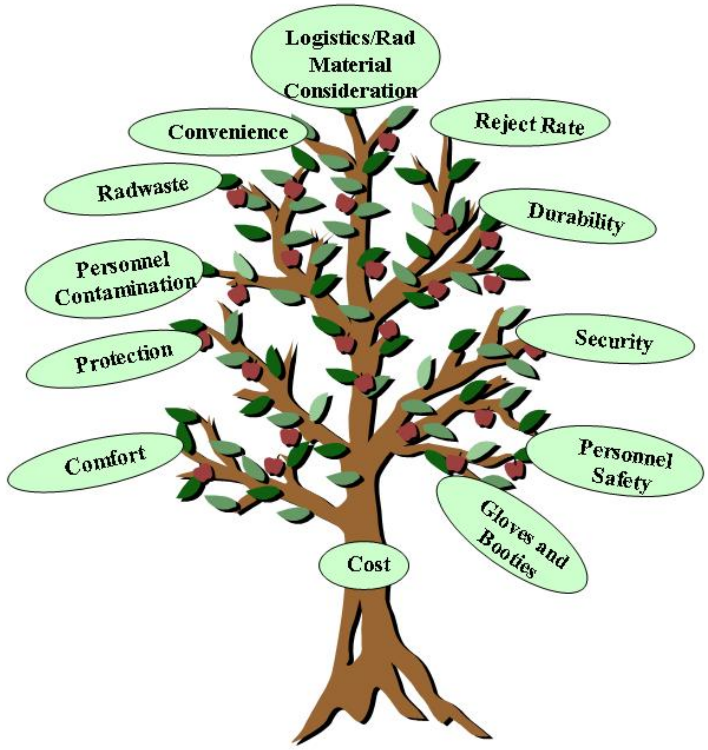

Fig. 1. Decision Tree

Nature of Decommissioning Work

Plants undergoing decommissioning should consider the nature of the work compared and contrasted to typical work at operating nuclear facilities when evaluating the interrelating factors. Workers are performing demolition as opposed to disassembly/reassembly. There are heavy physical work demands compounded by heat (ambient air temperature). There are unique industrial safety aspects such as sharp objects. The types of tools used create hazards as well. Cutting torches and saws are just two examples of tools that can quickly cause harm if not used correctly. Lastly, there is often exposure to radiation sources for long durations.

Figure 2 shows a worker using a cutting torch.

Fig. 2. Worker Using Cutting Torch

With this perspective on the nature of decommissioning work provided, the Decision Tree factors will be discussed further.

Comfort

Physical demands/sizing are important factor as they affect the ease to work in the garment. Garment design can be a limiting factor relative to comfort. Heat stress considerations should be evaluated which include:

- Vapor Resistance (Air Permeability – ASTM D 737-96)
- Thermal Resistance including performance in wet vs. dry conditions (Human Model Test ISO 11092 measures both vapor and thermal resistance)

Lastly, garment weight affects comfort and can be decidedly different when wet vs. dry. There are a number of references from scientific sources that should be consulted (see reference section).

Protection

- Durability
- Ability to avoid penetration
- Performance in varying environments (wet/dry/hot)
- Ability to absorb or repel liquids
- Performance when sweating occurs
  - Capillary action

Applicable Standards:

ASTM D 1683-04 – Seam Strength
ASTM D 3786-01 – Bursting Strength
ASTM D 3884-92 – Abrasion Resistance
ASTM D 5034-95 – Breaking Strength
ASTM D 5587-96 – Tearing Strength
ASTM F 903-99a – Water Intrusion
IES RP.COO3.2 – Particle Penetration

An evaluation was performed to determine if results would or could be different based on the cause of the PCE. Table II Personnel Contamination Event Causes shows this relative comparison.

Table II. Personnel Contamination Event (PCE) Causes

Plant Conditions	Relative Comparison of Launderable vs. SUPC
Unknown Reason	Launderable/Single Use Same
Improper Undress	Launderable/Single Use Same
Improper Controls	Launderable/Single Use Same
Poor Work Practices	Launderable/Single Use Same
Airborne	Launderable typically better barrier vs. airborne (due to thickness)
Not Enough PC's	Single Use better if you buy extra ($$) in right size distribution
Contaminated Thru PC's	Do barrier testing, this can go either way based on type of single use or launderable.
PC Sweat Through	Greater with most single use, due to thinness. See if PC's absorb/repel water.
Contaminated From PC's	Launderable greater – consider lower limit or different PC's.
Torn Protective Clothing	Greater with single use, 30% ripout report.

It can be concluded that one should not think that a change to single use will reduce PCE's. Real causes need to be well understood so that cost-effective mitigation can be implemented.

Table III. How Many Personnel Contaminations Really Caused by PC’s

PCE Reduction of PC’s	Cost Factor
Better Housekeeping/Facility Decon	Cost Medium
Improved Training	Cost Low/Medium
Radiological Work Permit Review/Right Protection for Job	Cost Low/Medium
Consider Single Use Over Launderable for Certain High Contamination Jobs	
Understand Your Processor’s Laundering Cycle/Technique	Cost Zero
Lower Reject Limits	Typically Cost is Low
New PC’s	Cost High/Evaluate Rental/Lease
New Single Use	Cost High/Almost Double Launderable on a Cost Per Use Basis

After causes are identified, evaluate the most effective way to reduce.

Table IV. Convenience

Single Use Process	Launderable Process
1. Shipment arrives at site (30,000 sets)	1. Shipment arrives at site (2,000 sets)
2. Security screens	2. Security screens
3. Boxes moved to dress-out area (can be outside of RCA)	3. Move pre-loaded carts/mobile shelving to dress-out area
4. Boxes loaded onto shelving	4. Issue PC’s and other clothing out of carts/shelving directly
5. Personnel dress-out and use	5. Collect dirties in same carts
6. Dirties collected	6. Move to shipping area
7. Rad shipment prepared	7. Rad shipment prepared
8. Shipment sent	8. Shipment sent
9. Zippers/other waste returned	
10. Zippers/waste dispositioned with other radwaste	

Reject Rate

Reject rate is the limit at which laundering facilities reject laundry due to the amount of residual contamination that remains on clothing after laundering. The radioactivity in the garment is measured by monitoring equipment that is specifically designed for the application.

The following factors affect the reject rate:

- Type of Fabric
  - Synthetic, Rubber, Cotton, Poly/Cotton
- Decontamination Properties
- Construction and Quality of Fabric
  - Velcro, Zippers, Pockets, Seams
- Work Environment
- Set Point Limits (Level of Detection)
- Monitoring Equipment
- Required Mending
- Age of Protective Clothing

The factor that has the greatest impact on the reject rate is the set point limits (level of detection) of the monitors. If the reject rate is high, a user can consider raising the set point limits slightly to achieve fewer rejects.

Durability

Durability of the garment should be considered in the overall analysis. Garment durability can cause cost impacts in several ways. When a single use garment breaks, an employee must exit the area and change into another garment. There is a lost of productivity and loss of the cost of the garment. A launderable garment may not become damaged under the same conditions. If it does, it may be able to be repaired, avoiding the cost of the loss of the garment. Consider the following areas when considering durability:

- Breaking Strength (ASTM D 5034-95)
- Tearing Strength (ASTM D 5587-96)
- Seam Strength (ASTM D 1683-04)
- Bursting Strength (ASTM D 3786-01)

Personnel Safety

Personnel safety always ranks as the top priority in any industry. Careful consideration should be given to evaluate the safety implications of a garment. Heat stress could be an issue if a garment does not breathe well or causes sweating. Stocking and shipping have caused some back injuries in the industry. Fire protection of individuals is paramount when working around/with torches, open flames, sparkles, or energized circuits.

Although cost is important, safety remains the number one factor when considering types of protective clothing.

Logistics/Rad Material Considerations

In some cases this is a key factor because of plants' space limitations of storage area size and location. RCA or Non-Rad Area can affect efficiency and cost. Storage of PC's in dress-out location can be a factor, as is the available space and shipment minimization. As an alternative to switching, consideration should be given to working with your laundry service to minimize logistics issues. Consider pre-staging, leasing, and specially designed carts and mobile shelving.

Security

In the post 9/11 environment, the level of security at nuclear installations has increased to where searches are required of all shipments prior to entry into the Owner Controlled Areas. In addition, searches are also required prior to Protected Area entry.

The logistics of material and dress-out location interrelate to these security issues. Careful consideration should be given to create processes to minimize the impact and associated costs of security searches.

Survey of U.S. Commercial Nuclear Plants Currently Undergoing Decommissioning

A survey was conducted of the following plants to determine their PC usage:

- Maine Yankee
- Connecticut Yankee
- Yankee Rowe
- Saxton
- Big Rock Point
- Trojan
- Rancho Seco
- SONGS

All of the plants were using launderables as they felt that they best met their overall needs.

Cost

Cost is becoming the second strongest driver in decision making at operational nuclear plants, plants undergoing decommissioning, and DOE facilities. A cost analysis should be performed to determine the overall comparative cost of laundering vs. SUPC. Below is a table in Excel Spreadsheet format for doing a simplified cost analysis based on a "cost per use basis". Note: The author will have CD's available of this analysis spreadsheet for individuals who attend the Poster Session.

Table IV. Simplified Cost Analysis for Selecting Protective Clothing

	Cost	Launderable	SUPC
A	Total Annual Dress-outs		
B	- Existing Inventory		
C	+ # of Uses Per Garment		
D	+ % Damaged or Contaminated Reject Rate		
E	= Total Required Annual Inventory (Purchase Cost)		
F	Receiving Cost (Amortized Over Shipment)		
G	Shipping Cost (Amortized Over Shipment)		
H	Laundering Cost		
I	Radwaste Cost (Include all that applies, Dissolving, Volume Rates, Burial		
J	Total Cost		
A	Total Dress-outs		
K	J ÷ A = Total Cost Per Dress-Out		

Estimated Savings Launderable vs. SUPC for a Typical Decommissioning Project
Based on a range of costs the following demonstrates the estimated savings:

$1.30 - $3.00 US per Dress-Out x 200,000 Dress-Out Over 8 Years = $260,000 - $600,000 Total Savings. 200,000€ - 500,000€ Total Savings.

CONCLUSIONS

Individuals considering using SUPC should not jump to conclusions. An evaluation should be performed to understand the facility's true drivers for selecting clothing. The right questions need to be asked and answered by the company providing the clothing to formulate a proper perspective and conclusion. In the end, the individual making the recommendation should ask himself/herself – "Is my decision emotional, logical, or economical?

REFERENCES

1. Air Permeability – ASTM D 737-96
2. Vapor and Thermal Transport Resistance – ISO 11092
3. Water Intrusion – ASTM F 903–99a
4. EPRI Report – Guidelines for the Optimization of Protective Clothing – November 2003
5. Breaking Strength – ASTM D 5034-95
6. Seam Strength – ASTM D 1683-04
7. Tearing Strength – ASTM D 5587-96
8. Abrasion Resistance – ASTM D 3884-92
9. Bursting – ASTM D 3786-01
10. Particle Penetration – IES RP.COO3.2