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DUF6-MCS-18-00614

Reinhard M. Knerr, Contracting Officer's Representative
U.S. Department of Energy
Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513

Subject: Technical and Regulatory Evaluation of Heel Size
Prime Contract No. DE-EM0004559, DUF_6 Conversion Project

Reference: Letter from R. Knerr to A. Parker, "Request for Technical and Regulatory Evaluation of Heel Size" (PPPO-01-4806270-18), dated April 12, 2018

Dear Mr. Knerr:

As requested in the above-referenced letter, Mid-America Conversion Services, LLC hereby submits Engineering Evaluation EEV-U-VPA-012-18, Technical and Regulatory Evaluation of Heel Size.

If you have any questions, please contact Kirk Barlow, Fellow Engineer, at (270) 538-2055 or me at (859) 685-9272.

Sincerely,

Alan M. Parker
President and Project Manager

Attachment: Engineering Evaluation EEV-U-VPA-012-18, Technical and Regulatory Evaluation of Heel Size

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Title: Technical and Regulatory Evaluation of Heel Size	
Responsible Engineer: Kirk Barlow	
Date: 8-28-18	

1.0 Summary

This evaluation documents Mid-America Conversion Services, LLC's technical and regulatory evaluation of DUF_6 heel size per DOE's request in Reference 1. The evaluation examines all facets of cylinder processing that would be impacted by an increase in the residual mass in the cylinder after processing. The study concludes that it would be advantageous to the DUF_6 Project to increase the heel size from the current limit of 22 Kg to an increased heel size of 71 Kg. Optimally, the DUF_6 process would be concluded when the cylinder does not have enough pressure to sustain nominal DUF_6 flow rates without using the vacuum pumps. To accommodate an increase in mass remaining in the processed cylinders, the DUF_6 Project would require physical modifications to the existing facility and additional funding which are currently not included in the current baseline. Documentation describing cylinder heels and/or heel processing would require revision, as would operational procedures for the affected systems.

Due to the discrepancies associated with nomenclature describing material remaining in the cylinder after processing, it is recommended that the DUF_6 Project generate a new term for an increase in this mass. The term 'Heel' is widely recognized as 25 lbs for 30" cylinders and 50 lbs for 48" cylinders. For the purposes of this study, the term for a cylinder with an increased mass after processing will be 'Processed Cylinder'.

Another recommendation from this study is for the project team to evaluate a multifunctional cart that would be able to accept Processed Cylinders, relocate Processed Cylinders to the aging yard and the CSS area, rotate the cylinders, relocate the cylinders to the CMS area and serve as a cradle for cutting and welding operations. The multifunctional cart would be designed to interface with a normal forklift for material handling. This multifunctional cart could provide many benefits by eliminating several lifts (Efficiency) per cylinder and eliminating work in close proximity to the cylinder, primarily associated with the lifting fixture (Safety / ALARA).

2.0 Detailed Problem Statement

As the DUF_6 Project is seeking methods for increasing processing rates, one of the anticipated constraints will be cylinder change-out cycle times. A major contributor to the current cycle time is heel removal, which takes approximately 4 hours on average. If the DUF_6 Project were to

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allow processing to terminate when the cylinder is at a higher absolute pressure than the current accepted pressure, this cycle time could be minimized thus effectively mitigating the heel cycle time constraint.

Increasing the residual mass of DUF_6 in the Processed Cylinder, however, has impacts to downstream processes. These impacts are discussed in the study and weighed in a benefit vs cost type evaluation to draw final conclusions and recommendations.

3.0 Assumptions

1. DUF_6 approximates an ideal gas at ~atmospheric pressure and ~100° C
2. Maintenance of vacuum pumps will improve in proficiency as Reliability Engineering and System Health improvements are implemented

4.0 References

1. PPPO-01-4806270-18, *Contract No. DE-EM0004559: Request for Technical and Regulatory Evaluation of Heel Size*, April 2018
2. DUF6-C-DSA-001, Revision 13, *Paducah DUF6 Conversion Facility Documented Safety Analysis, Paducah, Kentucky*, April 2018
3. DUF6-C-DSA-001, Revision 15, *Portsmouth DUF6 Conversion Facility Documented Safety Analysis, Piketon, Ohio*, April 2018
4. DUF6-C-TSR-002, Revision 13, *Technical Safety Requirements for the DUF6 Conversion Facility, Paducah, Kentucky*, April 2018
5. DUF6-X-TSR-002, Revision 15, *Technical Safety Requirements for the DUF6 Conversion Facility, Piketon, Ohio*, April 2018
6. DUF6-U-HAZ-003, Revision 7, *DUF6 Conversion Facility Hazard Analysis*, April 2018
7. 49 CFR 173.417, *Authorized fissile materials packages*, October 2011
8. DOE O 435.1, *Radioactive Waste Management,* July 1999
9. DOE M 435.1-1, *Radioactive Waste Management Manual,* July 1999
10. U-CLC-CSS-0049, *H2 Generation Rates in Aqueous High pH*, April 2013
11. U-CLC-CMS-0050, Revision 2, *Calculation of the Burst Pressure for a 48G DUF6 Cylinder,* December 2013
12. EEV-U-CSS-002-14, Revision 0, *Allowable Corrosion Period for a Standard Heel Cylinder following Stabilization*, March 2014

5.0 Impact on Nuclear Safety

The mass of volatile DUF_6 remaining in the cylinder after processing is an initial condition in the Paducah and Portsmouth Conversion Facility Documented Safety Analyses (DSAs) (References 2 and 3). The initial condition is protected in the associated Technical Safety Requirements (TSRs) (References 4 and 5) under Specific Administrative Control (SAC)

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5.5.3.4L, Heel Cylinder Staging Acceptance Control. The cylinder heel mass is used within the DSA analysis as follows:

- To establish the nuclear hazard categorization in accordance with the requirements of DOE-STD-1027-92 of one of the four Conversion Facility segments (specifically, the Empty and Heel Cylinder Staging Area) that establish the facility as Nuclear Category 3,
- To establish the Material at Risk (MAR) for each hazard and accident analysis event involving heeled cylinders as documented in the separate hazard analysis (HA) document (Reference 6),
- As a source of hydrogen production through radiolysis after the heeled cylinder DUF_6 has been stabilized,
- As a source of hydrogen production from chemical reaction after the heeled cylinder DUF_6 has been stabilized,
- To establish the allowable time frame for corrosion of a standard heeled cylinder between stabilization and uranium oxide fill or solution neutralization.

An increase in the mass of DUF_6 remaining in the cylinder after processing could affect the analysis associated with each of the above. The effect on the DSAs and TSRs for the two Conversion Facilities and their supporting documents are discussed below for each item.

5.1 Facility Nuclear Hazard Categorization

The mass of the cylinder heel is used for facility nuclear hazard categorization pertaining to the Empty and Heel Cylinder Staging Area outdoor staging facility segment. Per the DUF_6 Facility Conversion Facilities DSAs (References 2 and 3), this segment is currently categorized as Nuclear Hazard Category 3 by maintaining the segment radionuclide inventory below the Hazard Category 2 threshold. The hazard categorization document determined that the Hazard Category 2 threshold could be reached if 3700 heeled cylinders with 50 kg of UO2F2 were stored in the area. The DSA reduces this to an inventory limit of 3,000 heeled cylinders in the area. This limitation is an initial condition within the DSA that is ensured by a SAC in the associated TSRs (SAC 5.5.3.2, MAR Inventory Control).

An increased in the heel mass could affect the number of Processed Cylinders allowed within the Empty and Heel Cylinder Staging Area. The hazard categorization document would be reviewed and revised if necessary to establish a new maximum number of 'Processed Cylinders' to maintain the facility hazard categorization at Hazard Category 3. The DSAs and TSRs would need to be updated as appropriate if the maximum number of heeled cylinders is revised. As-is, the sites can likely store approximately 900 cylinders based on physical constraints. Therefore a scaled reduction of the threshold number of cylinders (from 3,700 - 1,150), is not likely to create a logistical constraint that would be physically challenged. ***No anticipated impact***

5.2 Heeled Cylinder Material at Risk (MAR)

The cylinder heel mass is an initial condition of the hazard and accident analysis as the established MAR for a heeled cylinder. The cylinder heel mass is established within the DSA as

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the amount of volatile DUF_6 remaining in the cylinder after process and is ensured by TSR SAC 5.5.3.4L. The DSAs and TSRs would need to be updated to address the change in the initial condition.

Cylinder heel mass is first discussed in References 2 and 3, Chapter 2, *Facility Description*, both directly and indirectly and is used as a basis for the facility inventory evaluated in Chapter 3, *Hazard and Accident Analysis*. Specifically in References 2 and 3, cylinder heel mass is noted in the cylinder transfer system process discussion (Sections 2.5.1.2.2, 2.5.1.2.4, and 2.5.1.2.6) and the vaporization system process discussion (Sections 2.5.1.3.2 and 2.5.1.3.6). Cylinder heel mass is not directly discussed in the cylinder stabilization system (CSS) discussion (Section 2.5.1.8). However, the cylinder heel mass is the basis for amount of stabilizing liquid that is added to cylinder. An increase in the cylinder heel mass could affect this discussion. The documents establishing the parameters for the stabilizing liquid would require revision, as would the corresponding DSA discussion.

An increase in cylinder heel mass would affect the general unmitigated consequence analysis discussed in References 2 and 3 Section 3.3.2.3.3.1.1 and the low consequence events discussed in Section 3.3.2.3.3.1.2. Additionally, the cylinder heel mass is specified as the MAR in multiple hazard analysis events in the Hazard Analysis (HA) Tables C1 to C13 of Reference 6. Each heeled cylinder event in the HA Tables would need to be reviewed and updated as necessary to address an increase in the Processed Cylinder mass.

The use of the term "heel" is not appropriate if the cylinder's residual mass is increased. The DUF_6 Conversion Facilities establishes a cylinder as 'heeled' when the cylinder heel mass of volatile DUF_6 remaining in any cylinder type is below 22 kg (48 lb) based on pressure and temperature at the end of processing. This is not consistent with other UF_6 processing facilities, which establish a heeled cylinder by radioactive material mass within a cylinder using the mass limits in 49CFR173.417(a)(2) (Reference 7) for each cylinder size. Typical industrial practice establishes the radioactive material mass using accountability scales and the tare weight of the cylinder. The DUF_6 Project's method for determining cylinder heel mass is an approximation of the actual radioactive material mass, but may be off by as much as 136 kg (300 lb). For this evaluation, the mass of volatile DUF_6 remaining in the cylinder after processing is to be increased well above the 49CFR173 limits, therefore the use of a new term is considered appropriate. The new term coined for the purposes of this study is Processed Cylinder. The HA document, DSAs and TSRs would need to be updated to address the change in terminology should this change be implemented. However, since a significant increase in the mass of the 'Heeled Cylinder' has been accounted for in the hazards analysis, this change would not be expected to significantly impact the postulated consequence(s). ***No anticipated impact***

5.3 Hydrogen production through radiolysis after the stabilization of a heeled cylinder

In the hazard and accident analysis, the potential of a hydrogen explosion within the stabilized heeled cylinder is analyzed in DSA Section 3.3.2.3.4. One of the two potential sources of hydrogen within the cylinder is radiolysis of the water within the stabilizing liquid. The amount of hydrogen produced in the cylinder is dependent on the amount of radionuclides in the cylinder. The concentration of the hydrogen in the cylinder is dependent on the vapor space of the cylinder. Increasing the cylinder heel mass may slightly increase the amount of hydrogen

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produced and decrease the vapor space due to the increase of stabilizing solution. The calculation would require revision and the HA document and DSA updated as necessary. ***No anticipated impact***

5.4 Hydrogen production from chemical reaction after the stabilization of a heeled cylinder

In the hazard and accident analysis, the potential of a hydrogen explosion within the stabilized heeled cylinder is analyzed in DSA Section 3.3.2.3.4. The second potential source of hydrogen within the cylinder is chemical reaction of hydrofluoric acid (HF) in solution within the cylinder and the iron in the cylinder wall. The chemical reaction occurs during and after stabilization and stops only when the solution is neutralized, which may not occur until after the cylinder is modified into an oxide container and additional neutralizing chemicals are added to the cylinder. The production of a flammable concentration of hydrogen by chemical reaction is assumed to occur instantaneously within the cylinder during stabilization. An increased cylinder heel mass will not change this assumption or the hazard analysis and selected control set.

The calculation supporting the time to flammable hydrogen concentration (Reference 10) would need to be updated to evaluate a potential change of the unmitigated risk in multiple hazard analysis events. ***Impact discussed in 5.5 below***

5.5 Stabilized Standard Heeled Cylinder Allowable Corrosion Period

As noted in Section 5.4 above, HF inside the cylinder will chemically react with the interior cylinder wall (iron) to produce hydrogen within the cylinder which may approach a flammable concentration. This reaction may also corrode the interior of the cylinder such that over time a standard cylinder will not perform its safety function of containing a hydrogen deflagration. An allowable corrosion time period (13 months) between stabilization and uranium oxide fill or solution neutralization has been established. The time period was determined based on the allowable cylinder heel mass and the corresponding volume of stabilizing solution. An increase in the Processed Cylinder mass would directly affect this determination. The calculation and Engineering Evaluation determining this corrosion period (Reference 11 and 12 respectively) would need to be revised based on the Processed Cylinder mass and the new stabilizing solution parameters. Depending on the new mass and stabilizing solution, the time allowance between stabilizing a heeled cylinder and modifying a stabilized-heeled cylinder could be reduced. The References 2, 3, 6, 11 and 12 would require updating as necessary. ***RISK - Increased likelihood of hydrogen LEL exceedance in cylinder***

6.0 Evaluation

For the purposes of this evaluation, the most conservative and optimal case would be such that the Project would not have to utilize the vacuum pumps during normal processing. A study of all process line trends indicates that the cylinder pressure is reduced to approximately 0.15 bar(g) on average during normal processing (after processing to single conversion unit). Flow is terminated and then the vacuum pumps are turned on, commencing 'heel removal'.

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By not using the pumps during normal operation, throughput constraints realized from short-cycling the new cylinder heat up would be eliminated. In addition, maintenance costs would be significantly reduced, as would the safety risk associated with DUF_6 line breaks during pump change-outs.

Calculation of the expected residual DUF_6 is accomplished using the ideal gas law:

$$P * V = n * R * T$$

Where:

P = cylinder Pressure (bar absolute)
V = Volume of cylinder (m^3)
n = moles of DUF_6
R = Ideal Gas Constant
T = Temperature of cylinder (K absolute)

Rearrangement to solve for n:

$$n = \frac{P * V}{R * T}$$

Assume P = 1.3 bar(a) for a conservative value that can be reached during normal processing without the use of the vacuum pumps.

Cylinder Volume = 4 m^3

T = 100°C => 373 K

$$n = \frac{1.3\ bar * 4\ m3}{8.314e-5\ \ m3\ bar\ K-1mol-1 * 373K}$$

n = 167.67 mol

Mass DUF_6 ideal = n * MW_{DUF6}

Mass DUF_6 ideal = 167.67 mol * 352 g/mol = 59,020 g

Mass DUF_6 ideal = 59 Kg

Apply 20% margin for new definition of 'Processed Cylinder':

Mass DUF_6 remaining = 71 Kg

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Therefore, for this evaluation a newly defined Processed Cylinder would be ensured by processing to less than 1.3 bar(a) or 0.3 bar(g). For this case, the Heel procedure would require revision, incorporating a margin to ensure that the Project does not exceed 71 Kgs for any Processed Cylinder.

6.1 Process Impacts

6.1.1 *Vaporization (VAP)*

Based on the standard NRC/DOE definition of 'Heel' (Reference 7), the original DUF_6 Project design provided vacuum pumps to reduce the residual quantities in the DUF_6 cylinders to less than 50lbs and 25lbs respectively for 48" and 30" cylinders. To date, however, the project has not had a need to transport DUF_6 cylinders over the road or in DOT space.

Performance of the 'Heel Removal' process during normal processing adds an additional four hours on average to the cylinder processing cycle. At current production rates exceeding approximately 560 kg DUF_6/hr to a processing line, the DUF_6 Project experiences a high risk of becoming short-cycled during cylinder change-out. This means that operations personnel may have to reduce rates from the on-line cylinder to allow the new cylinder to fully heat prior to bringing it on-line. A less than fully heated cylinder affects rates as well, as the cylinder pressures generated may be less than required for stable production, again requiring a lowering of rates to allow the cylinder pressures to recover.

Optimally, for a Processed Cylinder, the vacuum pumps would not have to be operated thereby reducing cycle time on the back end of the cycle by approximately four hours. An additional benefit from a process control perspective is that it would lower the complexity of valving arrangements and minimize perturbations in DUF_6 flow which tend to upset the reactivity of the fluidized bed. All of these benefits are highly favorable in helping the DUF_6 Project achieve target throughput rates (77+ Kg/hr per nozzle). ***Benefit - Increased Throughput***

In addition to the process/throughput benefits, a significant reduction in maintenance support associated with the vacuum pumps would be realized. Currently, the Paducah site removes, refurbishes and replaces the vacuum pumps after a 6 month run-time as a Preventative Maintenance measure, which is a significant safety hazard (DUF_6 line breaks) as well as a significant cost. The Portsmouth site only replaces pumps upon failure. Each pump costs approximately $40K, and the DUF_6 Project has 20 pumps in service between the two sites (including those in the Cylinder Transfer System (CTS)). Table 1 below shows incurred costs of replenishing stock in the warehouse from vacuum pump repairs (and rebuild).

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iRen #	Desc	z	Pad POs	Qty Used in Pad	x	Ports POs	Qty Used in Ports	v	Average Cost	Total Cost
100263	Pump, Vacuum		PADP150584 MPAP170184	12		PTSP150568	5		41,365.50	703,213.50
100998	0-Ring, Viton		PADP150584	18		PTS150568	1		16.00	304.00
101080	Gasket Silver Plated 1/2" 1 EA		MPAP170204 MPAP170188	52		PTSP160076	5		4.40	250.80
101081	VCR Gasket			0		PTSP150205	5		1.70	8.50
101279	Soc. Hd Cap Screw 10-32 UNF x 1"		PTSP130304 PADP120932	2			0		7.00	14.00
101291	Valve Assembly		PADP150584 LEXP140029	18			0		194.00	3,492.00
101819	Insert, Hytrel Elastomer		C1800077 C1700590	6		PTSP150622	1		23.00	161.00
101918	Hub, 1/2" D-bore		PADP150476 PADP150108	6		PTSP120713 PTSP120516	7		375.00	4,875.00
Total Cost										**712,318.80**

Table 1. *iRen Extraction of Procurements to Replace Vacuum Pump Parts*

Based on the previous 2 years cost information (extracted from iRen) and assuming slightly improved maintenance performance, the overall savings would be significant; on the order of $300K/yr.

The vacuum pumps could remain installed for ensuring feed cylinders are below atmosphere prior to processing. Another consideration the DUF_6 Project should explore is utilizing the vacuum pumps in conjunction with chemical traps to provide a line-specific evacuation header to support Operations and Maintenance activities and to minimize the risk of a DUF_6 release. ***Benefits - Safety, Increased Reliability, Reduced Cost***

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6.1.2 *Conversion System (CON)*

As discussed in 6.1.1, minimal perturbations in DUF_6 flow would tend to allow for more stable fluidized bed conditions. This effect would translate into higher operating efficiencies resulting from both higher on-stream time, and higher average throughput rates. A rough estimate based on engineering judgment; reducing cycle time by approximately 3 hours per cylinder would result in an approximate 10% to 15% increase in throughput. ***Benefits - Increased Throughput, Increased Reliability***

6.1.3 *Cylinder Stabilization System (CSS)*

In order to stabilize a Processed Cylinder, a significant increase in the volume KOH solution injected into the cylinder would be required. To neutralize the Processed Cylinder contents, approximately 395 Kg of 20 wt% solution would need to be added. This equates to approximately 88 gallons. The current operational procedure adds two ten-gallon batches to the cylinder, therefore this operation would need to be drastically changed. Rather than use the original equipment (adding 10 gallon batches), a re-design of the system would be required to minimize potential administrative errors. A re-design to allow for a single larger batch would reduce the cycle time for stabilization.

It is also expected that the sloshing effects of an 88+ gallon volume of liquid in the cylinder would exacerbate current material handling problems (see Section 6.2). Alternatively, a smaller volume of more concentrated KOH solution could be used; heat of mixing and neutralization must also be considered in the re-design.

Based on the above discussion, to accommodate a higher volume of liquid in the Processed Cylinder, a capital project would be required to significantly modify the CSS. Due to pumping constraints of the currently installed KRS pumps, this new capital project would need to include a feed tank of KOH solution (or independent booster pump) specifically designed to feed the CSS independent of the KOH feed to the Process Off-gas System (POS), see Section 6.1.6 below. If an independent KOH feed tank and pump are considered, it is recommended that the KOH concentration in the stabilizing solution be increased to minimize the batch volume as appropriate. ***Cost - Moderate Capital Project***

6.1.4 *Cylinder Modification System (CMS)*

Similar to the CSS above, material handling considerations must be addressed in CMS. These considerations are discussed in Section 6.2 below. In addition, after modification, more adsorbent material would have to be added to accommodate the additional liquid. This administrative action is onerous and unsophisticated in nature. If the Project implements an increased mass for the Processed Cylinder, the system should be improved to accommodate additional adsorbent and lime addition,

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providing an engineered solution and making the introduction more precise. ***Cost - Moderate Capital Project***

6.1.5 <u>*Oxide Powder Handling System (OPH)*</u>

Processed Cylinders placed in the upenders would have approximately 7% less working volume compare to previously defined 'Heeled' cylinders. It is not anticipated that this decrease in working volume will impact the 1:1 ratio of oxide fill to DUF_6 feed. ***No anticipated impact***

6.1.6 <u>*KOH Regeneration System (KRS)*</u>

Currently the KRS supplies 20% KOH solution to the POS scrubbers and to the CSS batch tank via the KOH Filtrate Pump (PP-720). This pump is only sized to supply ~10 gpm 20% KOH at 30' total dynamic head (tdh), and ~20 gpm at 25' tdh. Current demand at the POS scrubbers is near 10 gpm, while the increased demand at CSS would be over 30 gpm with the implementation of increased mass in the Processed Cylinder. Thus, the KOH Filtrate Pump and its associated piping system are grossly undersized to handle both loads. In addition, using this system for the future demand would exacerbate a single point failure vulnerability in the process design. For that reason, an independent supply of KOH should be designed for Processed Cylinder stabilization. ***Cost - Small Modification (include in CSS Upgrade Capital Project)***

6.2 Material Handling

As previously discussed, the additional volume of liquid results in significant sloshing effects while moving the cylinder. A number of solutions to the unbalanced load have been discussed even in the current design. The most immediate and direct solution would be to implement double hook cranes at the CMS locations (both sites). Double hook cranes have already been implemented at CSS (both sites), but a similar modification at CMS is relatively complex. A rough order of magnitude estimate for double hook cranes at CMS is approximately ~$150K at each site. This solution, does not resolve any material handling issues on the VAP monorail, nor does it address issues that may occur at the OPH monorails near the upenders. To address the VAP monorail and the OPH Area cranes, an additional $100K is anticipated per site. ***Cost - Moderate Capital Project***

Recommendation for future consideration - an alternative solution may be to procure and/or design and fabricate several multifunctional carts that are either powered or can be movable with an electric (battery powered) pallet jack or tugger. The cart design should consider multiple applications for use in CSS, rotation of cylinder, relocation to CMS, welding and cutting (CMS), and other beneficial material handling tasks. It is anticipated that with a similar capital expenditure to the aforementioned crane modifications, a more beneficial solution may be available to the Project. ***Benefits -***

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Safety, ALARA (Reduced Dose), Increased Reliability (elimination of single point failures) and Efficiency (fewer crane evolutions). Cost - Moderate Capital Project

6.3 Nuclear Material Control and Accountability

Currently, when a cylinder has been partially processed through VAP, there is a mechanism under which the partially processed cylinder can be relocated back into the cylinder yard. When the cylinder is initially transferred from the Cylinder Yard to the Conversion Facility, it is removed from the Cylinder Information Database (CID). If the Project determines that it should return to the Cylinder Yard, then a new entry is made into the CID with the cylinder's updated weight information. The same process is followed for a 'Heeled' cylinder. Similarly, the same process would be followed for a 'Processed Cylinder'. ***No anticipated impact***

6.4 Transportation Impacts

Should the Project have the need to ship DUF_6 'Heel' cylinders (prior to stabilization), it is likely that a high percentage of cylinders processed to the current definition of 'Heel' would be able to be transported without over-pack protection. In the current case, the Project would still have to verify the mass in the Heel Cylinder with a certified scale prior to shipment. The Project could calibrate and certify the scale(s) in the OPH airlocks for this purpose.

For the 'Processed Cylinder' definition, however, shipments prior to stabilization would require over-packs. Due to tractor/trailer size constraints, this would relegate the Project to shipping one cylinder at a time over the road, and perhaps two at a time by rail. Logistically and from a cost standpoint, this would all but eliminate the possibility of stabilizing the 'Processed Cylinders' off-site. ***No immediate impact, but possibly eliminates future flexibility***

6.5 Disposal Facility Requirements

The major difference between the current oxide filled containers and proposed option would be attributed to the amount of liquid KOH added to the Processed Cylinder during stabilization. Up to approximately 100 gallons (if 20wt% KOH solution is used) may be added to the cylinder, rather than ~20 gallons presently. As discussed in 6.1.4 above, additional absorbent material would be added to the cylinder as necessary to ensure that the oxide container does not have free-standing liquid inside. Furthermore, since the package contents have not been characterized at this time, going forward, the oxide profile will be developed for approval by the long term storage contractor. ***No anticipated impact***

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Table 2 below summarizes the results of the discussions in Sections 5 and 6 above:

Issue	***Impact Description***	***Benefit****	***Cost***	***Risk***	***None***
Hazard Category	More mass in the cylinder after processing would impact the number of cylinders allowed to be stored on the Aging Pad				X
Material at Risk	Mass assumed to be included in an accidental release after processing			minor	
Hydrogen Production (radiolysis)	The amount of hydrogen produced by radiolysis is dependent on the amount of radionuclides in the cylinder				X
Hydrogen Production (chemical)	The amount of hydrogen produced by chemical reaction is dependent on the amount of HF in the cylinder after stabilization which could increase			minor	
Corrosion	Corrosion rates could increase as a result of more chemicals added			X	
Process (VAP)	Minimize cycle time issues with long heel removal. Significant reduction in maintenance of vacuum pumps.	S, T, R, C	Savings		
Process (CON)	Fewer bed perturbations, more stable operation.	S, T, R			
Process (CSS)	Additional KOH added to cylinder, unbalanced load, sloshing effects		Moderate		
Process (CMS)	Additional KOH added to cylinder, unbalanced load, sloshing effects		Moderate		
Process (OPH)	No anticipate change in mass of oxide loaded into container				X
Process (KRS)	Independent feed to CSS would be needed		Low		
Material Handling	Additional KOH added to cylinder, unbalanced load, sloshing effects		Moderate		

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NMC&A	No change to the current operation in how DUF6 Project transfers material from and back to cylinder yard (CID)				X
Transportation	No current transportation of heels over public highways - no change				X
Disposal	The additional liquid in the cylinder is small in comparison to the total volume of the cylinder itself. It is anticipated that the same amount of oxide can be loaded in addition to the larger batch volume of KOH solution.				X

* S=Safety, T = Throughput, R = Reliability, C= Cost

Table 2. Qualitative Summary of Benefits vs Cost/Risk

7.0 Conclusions and Recommendations

7.1 Conclusions

Based on the above discussions, several benefits could be realized by increasing the definition of a 'Processed Cylinder' from 22 Kgs to 71 Kgs.

- Personnel Safety Improvements - Lower maintenance and fewer conversion upsets resulting in significantly lower safety risk due to fewer DUF_6 line breaks and fewer conversion unit cleanouts (from unstable fluid bed upset conditions). This would also be a contributor to cost reduction and throughput
- Increased Throughput - it is qualitatively estimated that an operating line could experience an increase in daily production by approximately 10-15%
- Lower Cost (based on Higher Equipment Reliability) - while an insignificant amount of downtime is directly associated to pump failures, an estimated $300K/yr is currently spent replacing the vacuum pumps using the current operating strategy

In order to accommodate the increased mass of a newly defined 'Processed Cylinder', a moderate capital outlay would be required of the project involving modifications listed below:

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- Independent KOH feed to the CSS; either an independent booster pump from the current system, or preferably a new independent feed tank (with pump) using higher assay KOH (e.g. 45 wt%)
- CSS Batching re-design to accomplish stabilization in a single batch (batch tank re-sizing)
- Double hook cranes or other modification to address sloshing effects on VAP monorail
- Double hook cranes or other modification to address sloshing effects on the cylinder at CMS

It is estimated that the above capital modifications could be implemented at Portsmouth and Paducah for approximately $500K each site. Note that the cost of the recommended multifunctional cart has not been estimated.

7.2 Recommendations

Engineering recommends evaluating the possibility of providing movable, multifunctional carts with cylinder rotating capability as an alternate to double hook cranes in VAP, CSS, and CMS. This potential new material handling project (movable Processed Cylinder Carts) could result in additional Safety, ALARA, Reliability and Efficiency.

Furthermore, Engineering recommends evaluating re-configuring the existing vacuum pumps to provide a line-specific evacuation header for the DUF_6 piping.

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