LCM RISK ASSESSMENT	**AREA: Cast Hall**	**TITLE: Rare Earth Fluoride Plant Operational Risk Assessment**	**No. 1**

SCOPE:

DATE: 22/04/2021

ASSESSMENT UNDERTAKEN BY: Kagya Nyanin (Technical Manager)
Sean Bennett (Senior Maintenance Engineer)
Aaron Riley (Operations Manager)
Steve Jones (Health, Safety & Production Superintendent)
Vipin Pradeep (Process Engineer)
Jonathon Price (Process Support Technician)
Thangavelu Jayabalan (Health & Safety – Ineris)

REVIEW DATE: TBC (After installation of plant)

No.	HAZARD	EVALUATION (Consequence x likelihood) (1 – 25)	IDENTIFIED CONTROL ACTIONS (What is required, who will have responsibility- identify if no action required)	Residual Risk Rating	BY WHEN?	COMPLETE? (4)

Double Click In This Area To Fill In Details – Double Click In Main Area To Complete Form *INSERT MORE ROWS AS REQUIRED/DELETE THOSE NOT USED*

HAZARD Look for hazards that reasonably expected to result in significant harm or loss. 1. Slipping/tripping 2. Fire/explosion 3. Chemicals 4. Moving machinery 5. Working at height 6. Material movements 7. Electricity 8. Hot surfaces 9. Confined space 10. Pressurised systems, hydraulic systems 11. Dust/fume 12. Items falling from height 13. Manual handling 14. Noise 15. Lighting 16. Vehicles, mobile equipment, overhead cranes 17. Sharp edges, Impingements 18. Restricted space/access	**List hazards here** 1. Slipping/Tripping 2. Fire/Explosion 3. Chemicals 4. System Failure 5. Operator Error 6. Materials/Gases 7. Restricted Space/Access 8. Vehicles, Mobile Equipment, Overhead Cranes 9. Dust/Fume 10. Working at Height 11. Manual Handling	12. Noise 13. Pressurised system 14. Hot Surfaces 15. Electricity/Bonding
WHO MIGHT BE HARMED? Groups of people doing similar work or might be affected: A. Operators B. maintenance C. cleaners D. members of the public E. office staff F. contractors G. visitors H. inexperienced staff I. Member of the public	**List groups of people who are specially at risk from the hazards identified abov** A. Operators B. Maintenance E. Office Staff F. Contractors G. Visitors	
WHAT CONTROLS CURRENTLY EXIST? Is there adequate information, instruction or training? Are there adequate systems or procedures? Do the precautions :- - meet the standards set by legal requirement? (PUWER, Noise, COSHH etc) - comply with recognised industry standard? (BSS, Codes of Practice etc) - comply with company standards and rules? (TSW Policy) - represent good practice? - reduce risk as far as reasonably practicable? Indicate the precautions in place with reference to procedures, manuals, company rules etc.	**List existing controls here or note where the** information **may be found.** The furnace has PLC that monitors all potentially dangerous variables (pressure, temperature etc.) and puts the furnace in a safe position should any of these variables become out of tolerance. All materials used in the furnace have appropriate MSDS, COSHH or data sheet. The operational manual is kept in the Furnace File. Held in the project office	

FURTHER ACTIONS NECESSARY TO CONTROL THE RISK			SUBJECT: Fluoride Plant	DATE: 27/04/21		Page 3 of 17
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WHAT FURTHER ACTION IS NECESSARY TO CONTROL THE RISK? What could be reasonably practical to do to address those risks not adequately controlled? List the risks not adequately controlled and evaluate each hazard : ***(CONSEQUENCE X LIKELIHOOD)***	**Decide what action to take to control the risk, if possible in the following order :** - Remove, eliminate or reduce the risk to an acceptable level - prevent access to the hazard (guards etc.) - develop new or improved work controls – procedures , work methods, training, - use or improve PPE

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1.	**Slipping/Tripping** Assessing parts of the furnace (pipes, valves, reactor etc run at ground level causing trip hazard. Steel platform has stairs for access to top level of furnace with handrails fitted.	**3 x 3 = 9**	Space provided in the furnace enclosure for easy access to furnace parts. The enclosure should be well lit. The steel work is to be painted to bring attention to potential tripping points. All operators and engineers that work in the area are sufficiently trained on health and safety in the workplace and housekeeping.	**2 x 3 = 6**	Commisioning Complete	Check enclosure lighting and paint

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2.	**Fire/Explosion** Furnace uses HF which can react with certain metals to produce H2 gas which can cause fire with an ignition source.	**5 x 2 = 10**	Materials selected for components and pipes are designed to prevent reaction with HF. For high temperature and high concentration HF, materials used is monel or Inconel. For low temperature and low concentration, carbon steel is the material chosen. Other components such as valves/gaskets are specified to operate safely in HF environment. Process gas in reactor is 60 %(Ar)/ 40% (HF) for high temperature reactor process of up to 750 degrees Celsius. Control of work when system is in operation. In normal operation, personnel will be outside enclosure.	**5 x 1 = 5**		
	The furnace has electrical trace heating, pumps, motors and extraction fan	**4 x 3 = 12**	Temperature transmitters and pressure transmitters on components to put furnace in safe position if it goes above specified range. Pressure bypass line in case of overpressure in reactor. Pumps, motors are self monitored via the control system to ensure safe shutdown if in fault mode.	**4 x 2 = 8**		
	A concentration of hydrogen above the lower explosion limit (4%V) that is captured in a space restricting dispersion can be potentially explosive.	**5 x 2 = 10**	Materials selected for the components are specified as above. Verify if components are ATEX rated. See above comment for material selection and process gas in reactor. Consider H2 monitoring inside the container. Verify electrical components which could potentially spark.	**5 x 1 = 5**		

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3	**Chemicals** HF leaks from parts (evaporator, reactor, condenser, wet scrubber, and components (valves, flanges, gaskets etc) of the plant during normal operation may expose personnel to HF gas which is toxic in all routes of exposure (inhalation, skin contact, eyes, ingestion, which will cause harm and potentially fatal). .	**5 * 2 = 10**	Remote control and observation of the plant during start up, reaction phase where there is HF conveying through pipes, the reactor, condenser, and wet scrubber. Leak proof container to contain HF which is removed and neuturalised by the fluoride plant wet scrubber and the site wet scrubber after HF is detected by the HF analyser situated inside the container. Site emergency response if leaks overcome the enclosure. Main reactor, evaporator, condenser, wet scrubber, pipes, valves have been specified, designed, and manufactured to operate in HF environment, set parameters and to relevant standards. Equipment and components manufactured with materials to operate in the specified environment to minimise corrosion. Functional testing and certification of components to the required standards. Installation and commissioning of the plant by competent personnel and of plant. Plant is continuously monitored and controlled by PLC to ensure set pressure and temperature is within design specification. Safe shut down is initiated in an unsafe process condition such as high temperature and high/low pressure.	**5 * 1 = 5**	Functional testing report Commissioning plan : Cold and Hot	

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	HF leaks during visual inspection, feeding oxide and discharging product. HF exposure during maintenance due to leaks or intrusion into the plant	**5*2 = 10**	HF supply and Evaporator to be isolated by shut of valves during visual inspection. (Verify/Identify positive isolation of valves as specified and include in maintenance procedure) Before and after process start , the plant will be purged with Argon. Continuously monitoring of HF around the furnace during visual inspection and alarm if safe limit is exceeded. HF resistant PPEs and air flow respiratory mask (Confirm PPE required for plant operation) Controlled of work includes gas testing. Personnel training on plant operation, HF hazards/awareness training and HF First aid. Reactor and Evaporator designed to meet pressure regulation and tested to 10bar. (Verify standards)	**5*1 = 5**	Write operational procedures. Operational Training manual Training plan Look at confined space regulation.	
	Catastrophic failure of key equipment or components.	**5*2= 10**	Reactor is equipped with pressure relief valve to prevent pressure build up. Maintenance and inspection of key components Controlled shutdown and evacuation of HF into wet scrubber Emergency shutdown button and emergency response in site procedure	5*1 = 5	Identify PPE and First Aid Training Emergency Response plan	

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	Damage to HF drums in storage or when replacing empty drums with new full drums may expose personnel to HF.	**5*2= 10**	The HF drums are designed and manufactured to meet the standards required for HF storage. Follow manufacturer instructions for unloading and replacing new drums. Operation, and maintenance of HF storage equipment executed by trained personnel only. The HF drums will be housed in leaked proof enclosure with exhaust vent connected to the site wet scrubber. Control access to unloading and replacing of HF drums operation to key personnel. Safe working procedure and training of personnel by manufacturer Wear HF resistant PPE and self- contained breathing apparatus with oxygen supply . when unloading and replacing HF drums	**5* 1=5**	Detailed risk assessment and controls based on manufacturer work instructions. Confirmed designed standards, Verify certification of drums.	
	Potassium Hydroxide KOH, handling, topping up and connection/disconnection of IBC.	**4 x 2 = 8**	PPE specific for chemical handling, including full eye protection(goggles) alkali resistant glove/gauntlet. Check chemical resistance for standard jacket/trousers.	**4 x 1 = 4**		
	Chemical reaction/temperature build up in the scrubber due to lack of dosing of KOH	**2 x 2 = 4**	System balance and dosing should prevent this. pH continually monitored and dosing automatically adjusted. Manual check on pH and dosing every shift – Operational procedure.	**2 x 1 = 2**		

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4	**System Failure** Failure of furnace components could affect the process and control of the operational system.	**4 x 2 = 8**	Plant is continuously monitored and controlled by PLC to ensure set pressure and temperature is within design specification. Safe shut down is initiated in an unsafe process condition such as high temperature and high/low pressure. Maintenance schedule to be written and adhered to. Guidance will be given during commissioning and from ICMEA. Emergency stop button in control panel to shut machine down. Installation and commissioning of the plant by competent personnel. (Verify personnel) Factory acceptance testing at supplier's site. Operation/Maintenance manual available from the manufacturer.	**4 x 1 = 4**		

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5	**Operator Error** Potential risk of accidents due to a lack of training and experience of running the furnace.	**3 x 3 = 9**	Pre-familiarisation training to be carried out with operators. Comprehensive training to be given to each operator from the manufacturer during commissioning and testing. Work Instruction to be developed to capture more specific tasks such as feeding and discharging of the product. Operational manual provided by ICMEA and operators given training in accordance with the manual. In normal operation of the plant, personnel will be outside enclosure and controlled by control system inside site building.	**3 x 2 = 6**	Training plan with identified operators	

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6	**Materials/Gases** Furnace uses HF gas as atmosphere in process. A leak in the gas line could result in HF gases in container.	**5 x 2 = 10**	Leak- proof container with a negative pressure inside to ensure no HF release into the atmosphere. Gas detection inside the container detects a HF leaks and triggers a safe shutdown of the system along with evacuating any HF inside the container through to the plant wet scrubber where the HF will be treated. Wet scrubber in the plant is also connected to the site wet scrubber. All pipes are continuously welded and pressure rated. The furnace is leak checked prior to start and designed to be leak-proof components.	**5 x 1 = 5**		
	Argon is used as inertisation and process gas in the furnace. A large release of Argon due to leaks can act as an asphyxiant.	**4 x 1 = 4**	All pipes are continuously welded and pressure rated. The furnace is leak checked prior to start and designed to be leak-proof components. Consider to place an oxygen sensor in the area to detect any leak which could compromise the breathable atmosphere.	**4 x 1 = 4**		

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7	**Restricted Space/Access** Behind and underneath the furnace are tight spaces with limited or difficult access.	**2 x 2 = 4**	During normal operation there is no requirement to access behind or under the furnace as the plant will be operated via a control system inside the site building. RA to carry out by maintenance personnel for specific tasks. Maintenance procedures should be adhered to. Trained maintenance personnel to carry out specific tasks. Dedicated safety personnel outside the enclosure to ensure tasks safely conducted. (Verify confined space regulations)	**2 x 1 = 2**		
8	**Vehicles, Mobile Equipment, Cranes** A forklift truck or walk behind will be used to collect the discharged tray from the bottom of the furnace.	**2 x 3 = 6**	All personnel who will work on the furnace operation will be required to be adequately trained on any lifting equipment that they use.	**2 x 1 = 2**	Verify tray weight with product and manual handling of the product Review access to the plant Safe working procedures for feeding raw material and discharging of product	

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9.	**Dust/Fume** Leak in reactor causes dust from oxides. Potential dust when feeding of oxide into hopper. HF leaks causing fumes inside container.	 **3 x 2 = 6** 3 x 2 = 6 5 x 2 = 10	The process pressure is set to achieve bubble fluidisation to prevent oxide particles escaping the fluidisation zone / exiting the furnace. The Cyclone in the furnace remove dust from the process flue gas before treatment in the wet scrubber. Design integrity of reactor to relevant standards In normal operation, personnel will be outside enclosure. Trained operators and PPE worn when feeding (Dust masks) Safe working procedures to minimise dust generation during feeding. Refer to Chemicals	 **3 x 1 = 3** **3 x 1 = 3** 5 x 1 = 5		

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10.	**Working at Height** . Potential fall from height when accessing and descending stairs Fall from height when standing on top of the leak proof container to feed raw oxides	**4 X 3= 12** 5X3 =15	Handrails on around the stairs. 3-point contact when ascending and descending the stairs Stairs and handrails to be painted to highlight danger of trips and slips. Handrails around the edge of the container to prevent falling. Lighting on the stairs and around the container to improve visibility. Training and safe working procedures (To be reviewed during commissioning process)	**4 X 1 =4** 5 X 1=5	Confirm stairs and handrails are designed to meet required standards. Consider harness on task specific risk assessment.	
11.	**Manual Handling** Manually Feeding oxides and discharging the product may cause harm to personnel	**3 x 4 = 12**	The furnace capacity is 30kg per batch. Operators trained in manual handling. Limit maximum lifting weight to 15kg. Discharge product at about 10kg per time. (To be reviewed during commissioning process) .	**3 x 2 = 6**	Put in place safe working procedures.	
12.	**Noise** There is condenser (inside container)and chiller(outside container) that aid cooling of the process. Vibration system during the process	**3 x 3 = 9**	In normal operation, no personnel will be inside enclosure. Noise will require assessment during commissioning to decide if there is a need for hearing protection in the area during discharging of product/ maintenance During discharge process/maintenance the plant will be in safe mode with no vibration system in use.	**3 x 2 = 6**	Review noise level during commisioning Conduct a noise survey	

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13	**Pressurised System** over pressure in the reactor, evaporator, or mixing box can cause equipment damage leading to personnel being exposed to HF.	5X2=10	Remote control and observation of the plant during start up, reaction phase where there is HF conveying through pipes, the reactor, condenser, and wet scrubber. Reactor and Evaporator designed to meet pressure regulation and tested to 10bar. (Verify standards). Reactor is equipped with pressure bypass line to prevent pressure build up. Plant is continuously monitored and controlled by PLC to ensure set pressure and temperature is within design specification. Safe shut down is initiated in an unsafe process condition such as high temperature and high/low pressure. Factory acceptance testing at supplier's site. Installation and commissioning of the plant by competent personnel to ensure plant operates within designed specification .	**5X1 = 5**	Consider no access during cooling and shutdown – Safe working procedure	
	Poor maintenance and inspection could lead to failure of pressure vessels, valves, gaskets (Reactor and Evaporator)	5X2 = 10	Manufacturer to specify inspection and maintenance regime. Maintenance schedule to be written and adhered to by LCM. Consider to install camera inside container to assess condition inside container before maintenance tasks are conducted.	5X 1 = 5		

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14	**Hot Surfaces** Argon pipes leading up to the mixing box and pipes into the reactor as well as reactor itself will be considered as hot surfaces when in operation	**4 x 2 = 8**	During normal operation, no personnel will be inside container. Thermal insulation around the reactor and evaporator. After process ends, there is a cooling stage before product is discharged. Set temperature parameters in reactor before discharge to 30 degrees Celsius. Training of operators and PPE's to be worn	**4 x 1 = 4**	Include in operational procedure	
15	**Electricity/Bonding** Potential for electric shock if the plant is not properly bonded to earth. Incorrect isolation of plant during maintenance could potentially give electric shock	**5 x 2 = 10** **5 x 2 = 10**	Plant installed to BS7671 Standard Verified during commissioning. Competent and qualified personnel to carry out maintenance work. Control of work for maintenance.	**5 x 1 = 5** **5 x 1 = 5**		

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Risk Assessment Scoring Matrix

The current code structure for consequence fields in all incident impacts is provided as:

Consequence code descriptors for all incident impacts are as follows:

1 – Insignificant – no injury
2 – Minor – minor injuries needing first aid
3 – Moderate – up to 3 day's absent
4 – Major – more than 3 days absent
5 – catastrophic – deaths.

:
Likelihood is also a required field in the incident record. Current codes are:

5- Very likely – there's a 1 in 100 chance of the hazardous event happening
4- Likely – there's a 1 in 1.000 chance of the hazardous event happening
3- Fairly likely- there's a 1 in 10.000 chance of the hazardous event happening
2- Unlikely – there is 1 in 100.000 chance of the hazardous event happening
1- Very unlikely – there is a one in a million chance of the hazardous event happening

Consequence						
	5.Catastrophic	**5**	**10**	**15**	**20**	**25**
	4.Major	**4**	**8**	**12**	**16**	**20**
	3.Moderate	**3**	**6**	**9**	**12**	**15**
	2.Minor	**2**	**4**	**6**	**8**	**10**
	1.Insignificant	**1**	**2**	**3**	**4**	**5**
Likelihood		**1.Very Unlikely**	**2.Unlikely**	**3.Fairly likely**	**4. Likely**	**5. Very likely**

Red & Amber colours are deemed to be significant with regard to environmental impact
For grading risk, the scores obtained from the risk matrix are assigned grades as follows:

C-Code	Rating	Risk Status	
	1 - 4	Acceptable	No further action but ensure controls are maintained
	5 - 9	Adequate	Look to improve at next review
	10 - 16	Tolerable	Look to improve within specified time scale
	17 – 25	Unacceptable	Stop activity and make immediate improvements