UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
WASHINGTON, D.C. 20555

February 21, 1992

NRC INFORMATION NOTICE 92-14: URANIUM OXIDE FIRES AT FUEL CYCLE FACILITIES

Addressees

All fuel cycle and uranium fuel research and development licensees.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to the potential for fires involving uranium dioxide (UO_2) powder at various stages of transfer and conversion. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not new NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

In licensed fuel-fabrication facilities, there have been one recent and several past incidents of fires involving uranium at various stages of oxidation. The circumstances of two of them are described below in some detail.

Incident 1:

In the most recent incident, a fire was discovered, in a fuel-fabrication facility, involving a hood, hopper, and feed-screw assembly, which was being used to transfer calciner drop powder (uranium oxide) to a nitric acid dissolver tank. (See Figure 1.) According to a report submitted by the licensee, an operator had started to feed a batch of the powder into the dissolver tank when the feed-screw of the Model 608 Accu-Rate feeder stopped. The operator reversed the screw and tapped on the tube-shaped nylon screw-housing, to free the screw. At this time, he observed smoke and sparks coming out of the equipment below the hood. A small crack in the vinyl side of the feeder hopper, apparently the result of contact with the hot powder inside the hopper, was also noticed. The operator and other employees then donned full-face respirators and removed approximately 18 kg of the powder, leaving about 2 kg of powder that could not be removed, in the screw-housing. Meanwhile, the small crack on the side of the hopper had developed into a baseball-sized hole, spilling some powder onto a platform below. The employees cleaned up the spilled powder. Assuming that the incipient fire had been extinguished, the employees then left the area.

Approximately one hour later, fire alarm bells sounded throughout the plant, and the source of the fire was determined to be the same hood and feeder assembly that the employees had been working on. When plant emergency team members, dressed in protective clothing and using self-contained breathing apparatuses, entered the room, they found the visibility reduced to about 1 or 2 feet, because of the heavy smoke. Using portable dry chemical and carbon dioxide fire extinguishers, they extinguished the fire within 15 minutes of the alarm bells sounding.

All components of the hood and the Accu-Rate feeder that were made of combustible material (e.g., the nylon feed tube, vinyl hopper, rubber parts of a valve, and "Lexan" faces of the hood) were consumed by the fire. The primary stage of the high-efficiency particulate air (HEPA) filter for the room was loaded with soot, and the pre-filter was burnt. The fire alarm bells stopped ringing after about 3 minutes, as the alarm circuitry in the room was damaged by the fire. This confused some employees, who could not tell whether the emergency was over.

The incident exposed a weakness in the emergency communications system between the licensee and the local city fire department. Shortly before the incident, the facility had tested a newly installed extension of its fire alarm system, in conjunction with the fire department. Even though the facility had notified the fire department that the test was over, the fire department mistook the alarm, which came in about 18 minutes later, to be merely a continuation of the test. A 911 call was needed to alert them of the real emergency. Precious minutes were lost. Fortunately, by the time the fire department arrived, the plant emergency team had suppressed the fire.

In other observations, some employees thought that the alarm bells in some areas were not loud enough. Voice communications over the public address system were misunderstood by some employees and not heard by others, especially in the office areas.

The cause of the fire is believed to be the oxidation of the calciner drop powder consisting principally of uranium dioxide (UO_2), but also including other unstable oxides of uranium, which could further oxidize at elevated temperatures. The friction of the feed-screw sliding on the powder or on the nylon tube, which could have been warped, could conceivably have contributed to heating the powder.

Incident 2:

In another incident, at another nuclear fuel-fabrication facility, a fire was reported to have occurred in a slugger press containment housing. In this configuration, uranium oxide powder, following a blending process, was gravity-fed from a second floor hammermill baghouse through a 4-inch diameter x 6-foot long "Viton" hose to a first floor slugger press. The Viton hose was connected to the slugger press shuttle by a "Neoprene" boot. The slugger press shuttle area, including the Viton hose and the

Neoprene boot, was enclosed by the containment housing, which had two Lexan panels for access to the shuttle area. Containment ventilation was provided through primary and secondary HEPA filters and a water scrubber, before exhausting to the environment.

In this incident, the operator noticed that the granulator downstream of the slugger was not discharging powder. Apparently, this was not an unusual occurrence, and he started to arrange for replacement of the granulator screen, as was the normal practice. He then noticed a fire in the slugger housing. The ventilation system smoke detector had by that time sensed the fire and alarm bells were sounding. Employees extinguished the fire within minutes using portable carbon dioxide fire extinguishers. All of the combustible elements in the containment between the hammermill and the slugger press (e.g., the Viton hose and the Neoprene boot, as well as the Lexan parts of the containment housing) were consumed by the fire. The primary HEPA filters were extensively damaged. The secondary filters, however, were intact. In this case, also, heat generated by oxidation of the powder, which ignited the Neoprene boot, was judged to be the cause of the fire.

In other incidents, dating back to 1977, several fires involving calciner discharge lines and at least one involving a hammermill hood have been reported. In all cases, the oxidizing uranium powder was believed to be the source of ignition, and combustible materials, such as transfer hoses and boots, provided the fuel. All the fires were promptly extinguished.

Discussion

It has been common experience that unstable uranium oxide feed material (comprised mostly of UO_2, with a few other oxide forms present) in granulated form and in contact with oxygen undergoes exothermic oxidation reactions. In some cases, the heat generated by the reactions ignites combustible elements of the transfer passages or other powder-handling equipment (e.g., hoses, boots, etc.), which then contribute fuel to the fire. The fires described above have this commonality of cause and effect.

The fuel fabrication process generates several oxides of uranium. The final and most stable oxide is UO_2. The literature on uranium chemistry describes oxidation reactions that are complex, with their rates, heat evolution, and final products depending on several parameters, but most importantly on the fineness of the powder and the temperature. Indeed, according to one author*, normally stable UO_2 may be pyrophoric or oxidize rapidly even at room temperatures when in very fine powder form (specific surface area >10 m^2/g). Coarser powders, as is more commonly the case, may require elevated temperatures (>300°C) to oxidize. The account of the most recent fire suggests that elevated temperatures may have been generated by the Accu-Rate feed-screw binding on its nylon housing. Friction of the granulated material in motion may also have generated heat that raised the temperature.

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* Cordfunke, E.H.P., The Chemistry of Uranium, Elsevier Publishing Company, 1969.

Since, by the very nature of the manufacturing process, unstable uranium powder must be handled, certain preventive measures should be taken in order to reduce the potential for fires; and many of these have been adopted at licensed facilities. They are:

1. Limit the type of feed to stable powder whenever possible.

2. Store unstable powder in closed metal containers.

3. Replace the combustible components of powder-transfer lines and of equipment, such as the Accu-Rate feeder, with components made of noncombustible materials, as far as practicable.

4. Require an operator to be present when a process is under way, and improve visibility around vulnerable equipment.

5. Incorporate fire safety of vulnerable equipment in the operator training program, including use of portable fire extinguishers.

6. Implement a preventive maintenance program for vulnerable equipment. Periodic inspection may alert the operator to telltale signs of overheating.

Additionally, the following measures for upgrading the fire detection, alarm, and suppression systems may be considered:

1. Install fire detectors in hoods and equipment exhaust ducts. These detectors should be connected to a central panel, which is continuously supervised.

2. Check alarm system wiring for vulnerability to fire and reroute, if necessary and feasible. Implement a manual restart procedure, if alarm circuitry is partially disabled and the alarm stops.

3. Upgrade the alarm system and public address system for audibility, if necessary.

4. Add visible alarm signals in noisy areas.

5. Install carbon dioxide total flooding or local application system in equipment enclosure. For use and limitations of such systems, see NFPA-12, "Standard on Carbon Dioxide Extinguishing Systems," published by the National Fire Protection Association. This should not preclude the availability of portable fire extinguishers of both carbon dioxide and dry chemical types.

Some lessons on emergency communications may be learned from Incident 1 above. Some protocol should be established between the facility and the offsite fire department so that emergency calls are not misunderstood. Licensees should consider reviewing this information notice with their local fire department. The public address system announcement of an emergency and related directives should follow standard wording that is familiar to all employees and minimizes misunderstandings.

Fuel cycle licensees should review the Branch Technical Position (BTP) on Fire Protection for Fuel Cycle Facilities, published in the Federal Register (54 FR 11590-98) dated March 21, 1989. Licensees should examine their facilities, procedures, and records to assure that the stipulations of the BTP are met or exceeded.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate regional office.

Richard E. Cunningham

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Office of Nuclear Material Safety
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(301) 504-2536

Charles H. Robinson, NMSS
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Attachments: Computer Printout: see Jacket
1. Figure 1
2. List of Recently Issued NRC Information Notices
3. List of Recently Issued NMSS Information Notices

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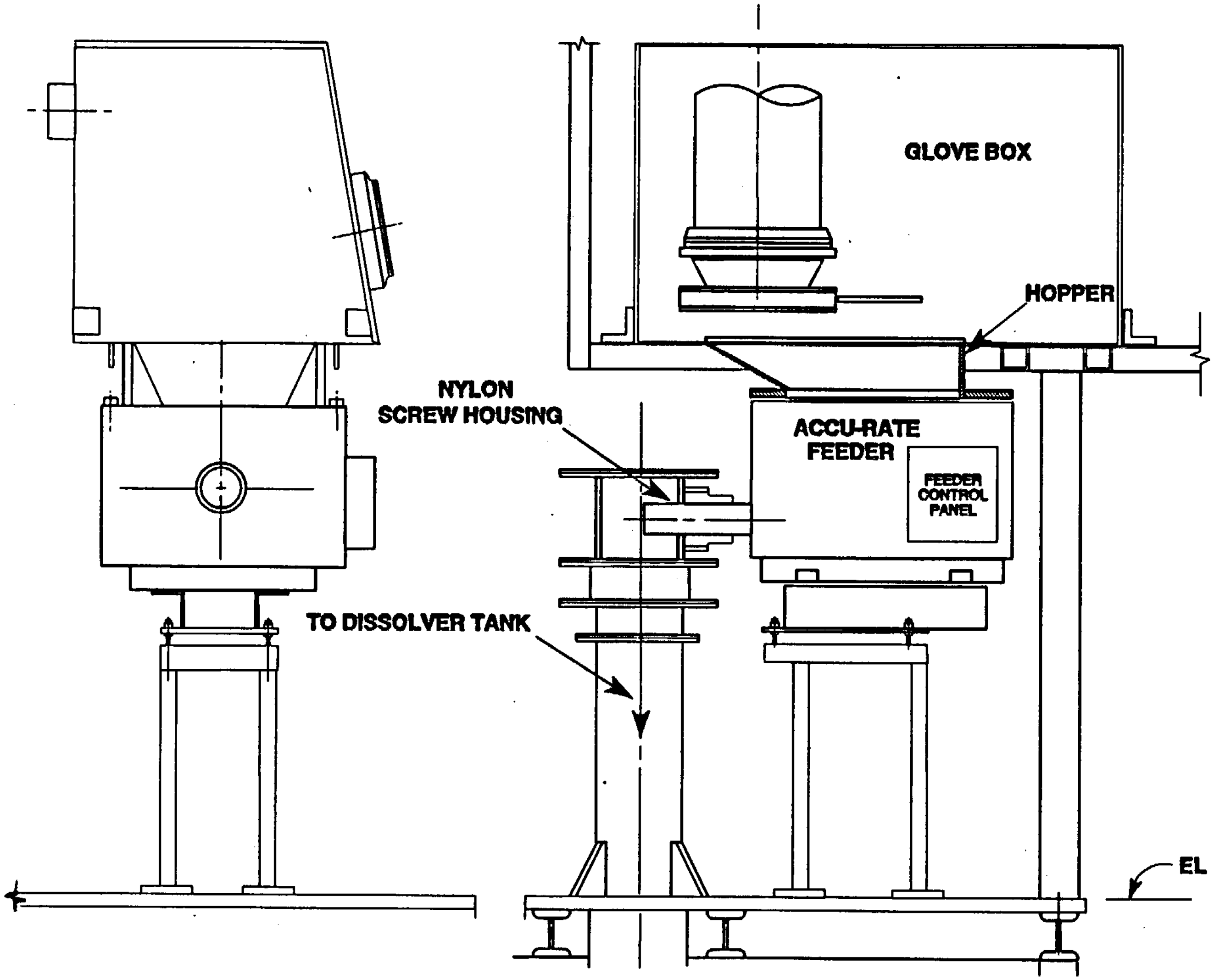

Figure 1. Uranium oxide feeder assembly.

LIST OF RECENTLY ISSUED
NMSS INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
92-11	Soil and Water Contamination at Fuel Cycle Facilities	02/05/92	All uranium fuel fabrication and conversion facilities.
92-10	Brachytherapy Incidents Involving Iridium-192 Wire Used in Endobronchial Treatments	01/31/92	All Nuclear Regulatory Commission (NRC) licensees authorized to use iridium-192 for brachytherapy; manufacturers and distributors of iridium-192 wire for use in brachytherapy.
92-08	Revised Protective Action Guidance for Nuclear Incidents	01/23/92	All fuel cycle and materials licensees authorized to possess large quantities of radioactive material.
91-86	New Reporting Requirements for Contamination Events at Medical Facilities (10 CFR 30.50)	12/27/91	All licensees authorized to use byproduct materials for human use.
91-84	Problems with Criticality Alarm Components/Systems	12/26/91	All Nuclear Regulatory Commission (NRC) fuel cycle licensees, interim spent fuel storage licensees, and critical mass licensees.
91-71	Training and Supervision of Individuals Supervised by an Authorized User	11/12/91	All NRC medical licensees.
91-66	(1) Erroneous Data in "Nuclear Safety Guide, TID-7016, Revision 2," (NUREG/CR-0095, ORNL/NUREG/CSD-6 (1978)) and (2) Thermal Scattering Data Limitation in the Cross-Section Sets Provided with the KENO and SCALE Codes	10/18/91	All fuel cycle licensees, critical mass licensees, interim spent fuel storage licensees, and all holders of operating licenses or construction permits for test, research, and nuclear power reactors.

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Information Notice No.	Subject	Date of Issuance	Issued to
92-02, Supp. 1	Relap5/Mod3 Computer Code Error Associated with the Conservation of Energy Equation	02/18/92	All holders of OLs or CPs for nuclear power reactors.
92-13	Inadequate Control Over Vehicular Traffic at Nuclear Power Plant Sites	02/18/92	All holders of OLs or CPs for nuclear power reactors.
92-12	Effects of Cable Leakage Currents on Instrument Settings and Indications	02/10/92	All holders of OLs or CPs for nuclear power reactors.
92-11	Soil and Water Contamination at Fuel Cycle Facilities	02/05/92	All uranium fuel fabrication and conversion facilities.
92-10	Brachytherapy Incidents Involving Iridium-192 Wire Used in Endobronchial Treatments	01/31/92	All Nuclear Regulatory Commission (NRC) licensees authorized to use iridium-192 for brachytherapy; manufacturers and distributors of iridium-192 wire for use in brachytherapy.
92-09	Overloading and Subsequent Lock Out of Electrical Buses During Accident Conditions	01/30/92	All holders of OLs or CPs for nuclear power reactors.
92-08	Revised Protective Action Guidance for Nuclear Incidents	01/23/92	All fuel cycle and materials licensees authorized to possess large quantities of radioactive material.

OL = Operating License
CP = Construction Permit