Handling and Treatment of Low Level Waste in a Sorting, Drying and Compaction Facility in Changjiang, NPP Unit 1/2 – 14309

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ABSTRACT

For the NPP in Changjiang the Siempelkamp Nukleartechnik GmbH designed a semiautomatic facility for handling and treating low radioactive waste (see Figure 1). The main goal of this facility is to reduce the radiation exposure of the working personnel and protect them from contamination during the waste treatment process.

The waste is sorted in a glove-box manually and thrown into 200 l - drums. Afterwards the waste in the drums will be dried, compacted or both, according to its category. The filled drums are capped manually and finally measured for radiological declaration.

Figure 1 Mock-Up/ Installation of the sorting, drying and compaction facility in the workshop

INTRODUCTION

In 2012, Siempelkamp Nukleartechnik GmbH was awarded the contract for design and erection of a sorting, drying and compaction facility for CHANGJIANG NPP. This facility is part of a new NPP, constructed for the Hainan Nuclear Power Co. Ltd. All incurring low radioactive materials of plant operation are treated and filled in 200 l-drums in the sorting, drying and compaction facility, which is located in a building, where the drums are safely conditioned and stored temporarily until their final storage. During the treatment process the personnel has to be protected by shieldings for reducing the radiation exposure. The protection against contamination is even more important, especially during the sorting process.

Siempelkamp Nukleartechnik designed the facility with the purpose to replace manual working steps for reducing the radiation exposure as well as the contamination risk of the personnel. Increasing the output of

the waste treatment was of course also an important goal of this facility. Therefore the facility is featured with a programmable logic controller (PLC) for managing the process efficiently.

The sorting, drying and compaction facility consist of the following main components:

- Sorting box
- Pre-Compactor
- 2 Drum drying device
- Drum inspection device
- Drum handling system (conveyors)
- Process control system

THE SORTING BOX

For sorting the waste with the protection of the personnel against contamination the Sorting Box is designed as a glove box, which is able to keep a low pressure inside the box. As you can see in the Figure 2, it is equipped with three sorting positions in the sorting chamber and one working position in the feeding chamber. The waste bags, containing the low radioactive waste, are thrown into the feeding chamber of the sorting box, which is equipped with a probe for monitoring the dose rate of the feeding area. After opening the bags, the waste can be pushed into the sorting chamber of the sorting box and be sorted in the three drums which are docked under the sorting box. Furthermore the sorting box is connected to the Pre-Compactor by a channel for throwing compactable waste directly into the drum in the Pre-Compactor.

Figure 2 Front View of the Sorting Box

For easy working with the limited working range, which is caused by the gloves and the standing position, the sliding doors at the sorting chamber openings as well as the flaps for closing the insertion funnels are driven electrically. A benefit of that is that these flaps and doors are easily to interlock with each other for keeping the negative pressure inside the sorting chamber.

The drums, which are delivered under the sorting box by chain conveyors, are docked at the sorting box by docking rings which are lowering onto the drums hydraulically.

THE PRE-COMPACTOR

All the radioactive waste which is compactable will be compacted in the pre-compactor. The waste is compacted inside the docked drum. After the first compacting step, the drum can be refilled using the connection channel to the sorting chamber and the waste will be compacted again until the drum is completely filled with compacted waste. The filling level can be checked by the personnel through the inspection glass of the Pre-Compactor. The waste is compacted with an adjustable force of up to 300 kN which corresponds to a weight of 30 tons. To ensure that the drum will not be distorted or damaged by this pressure, two half shells encapsulate the drum and support it. The plunger is supported by four massive guiding rods to eliminate the chance of oil leakage.

The loading of the pre-compactor with empty or filled drums works automatically, controlled by the PLC. Also the compacting is controlled by it for monitoring the pressure force.

2 DRUM DRYING DEVICE

Figure 3 Front View of the 2-Drum-Drying Device

The 2-drum-drying device (see Figure 3) is designed for dehumidifying wet solid waste which will not meet the requirements for disposal (residual water has to be avoided in order to minimize a rotting and fermenting process). It is built up of two main components; the drying chamber and the heating/cooling unit. The drying chamber can be loaded automatically by the drum handling system with two drums. The heating/cooling unit with its heater raises the temperature in the drying chamber during the drying process up to 140°C with air circulation. After the heating process the condensation process begins. The condensate is collected in a tank and the condensed amount is displayed and recorded at the control panel of the facility (see Figure 6). When no more condensate accumulates the cooling process will be started and the whole drying process will end with reaching the preset limit temperature.

The drying process is controlled by the PLC as well and is monitored at the control touch panel. All the drying parameters like the inlet and outlet temperature of the drying chamber, the inlet and outlet temperature of the cooling water or the condensate amount are recorded and displayed at the touch panel.

Furthermore the drying device is equipped with a gas measuring system, which detects flammable and explosive gases in the circulated air and will cause a flushing with CO_2 if the concentration will exceed a limit value.

THE DRUM INSPECTION STATION

Figure 4 Back View of the Facility and inspection station

After the drums are filled and manually capped, the last step is the radiologic declaration. Therefore the filled drums will be driven to the inspection device, which is built up of a turn table and a stand with 6 dose rate probes (see on the right side in Figure 4). Three are positioned on the circumference of the drum, one on the top and one at the bottom of the drum. The sixth probe is mounted in one meter distance of the drum and its value is for declaring the transport conditions. The turn table will rotate 360° during the measurement and the dose rate is recorded. After a manually performed smear test all needed data for the radiologic declaration are recorded and the drum can be transported to the intermediate storage.

PROCESS CONTROL SYSTEM

An assembly of roller- and chain-conveyors is building the drum handling system, which allows the operator to drive the drums between the different components. In combination with the programmable logic controller (PLC) the process control system is able to transport the drums automatically. In automatic operation the operator is in charge of entering the commands on the control panel for driving the drums between the different positions, for starting the measurement in the drum inspection station and for starting

the drying process. Like it is shown in Figure 5 the control panel layout consists of buttons and lights for controlling the facility. A touchscreen control panel was not used, for keeping it simple and clearly arranged. Most of the buttons are for manual control of every single component, but the facility is controlled in automatic mode and therefore only the green marked buttons are used. The manual mode is only to be used for manual intervention or maintenance and repair. A video control system provides the operator with all needed views for controlling the facility in a separated room.

The standardized way of, for example compactable waste with moisture, is described in the following:

The waste is sorted in the sorting box into a drum, which was driven by the operator from the insertion station to the docking station. After the drum is filled the sorting personnel gives a signal to the operator by pushing the complete-button. The operator notices the signal and puts in the command for driving the drum into the dryer by pushing the relevant buttons on the control panel (see Figure 6) and the drum will be driven automatically into the dryer. The PLC always controls all relevant interlocks before starting a sequence. The operator starts the drying process after the drum has arrived and he has made sure that the correct drying parameters are inserted. After the automatic drying process the operator starts the sequence for driving the drum into the pre-compactor. The sequence ends with the drum docked inside the pre-compactor and ready for compacting. The sorting personnel starts the compacting process. The refilling and compacting of the drum will be repeated until the drum is filled. Thereafter the personnel gives a signal to the operator by pushing the complete-button and the operator will start the sequence for driving the drum to the capping station, where it is capped manually. After the operator notices the flashing completion-light of the capping station he starts the sequence for driving the drum into the inspection station. The measurement will be started by the operator as soon as the drum has arrived. After the signal that the smear test has been carried out, the drum will be driven to the removal position where it will be removed by a fork lift.

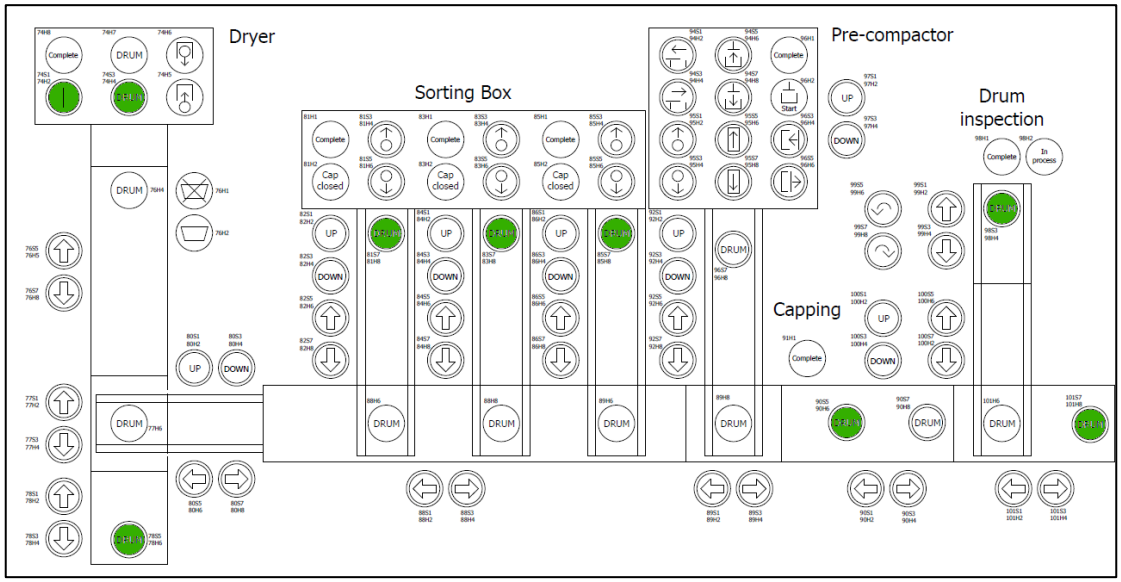

Figure 5 Layout of the facility implemented in the layout of the control panel

Summing up the operator has to start the sequences, but not to drive or control anything manually. He is in charge of the operating safety and the management of the facility. The PLC helps to focus on these tasks and

also support the operation a lot by interlocking impossible operations. Another benefit of this process control system is that the manual work is reduced to the following steps:

- Place empty drums on the feeding position (e.g. fork lift)
- Insert waste bags into the sorting box
- Sort the waste (open & close the flaps and sliding doors inside the sorting box)
- Start the compression in the Pre-compactor
- Manage the route of the drums through the facility (control panel)
- Remove the drum from the removal position (e.g. fork lift)
- Perform the smear test
- Cap the drums
- Place and remove the splash guards at the dryer

And the benefit from that especially is that only the last two listed steps are during exposure to the contaminated waste, but these are very short actions with low risk for spreading contamination. So the process of the treatment in this facility is not only more efficient, but it is really a very safe way to treat the radioactive waste.

Figure 6 Control Panel of the Facility

MOCK UP RESULTS

The complete installation of the facility for the shop test was very important, because all the interfaces the components have with each other are arranged before the installation on site, which cut down the effort on site on checking and adapting the interfaces with the customer's scope of supply. Furthermore the commissioning personnel was been trained in system installation and operation. Also the customer got a first impression of the whole facility during the shop test and was able to request changes and amendments, which were still being realized in the work shop.

The major problems which occurred during the pre-commissioning were:

The dimensions of the half shells of the pre-compactor did not match with the dimensions of the drum, because the dimensions of the shells were chosen to tight for the tolerated dimensions of the drum. For solving this problem the inner surface of the half shells was lathed and therewith the inner diameter was increased.

The handling of the sliding doors and of the flaps for the insertion funnels, which were moved by hand at first, turned out to be designed wrong. They could not be reached easily, because the working position is too limited by the gloves. It was necessary to contort and stretch oneself to reach the end positions. That is why it was decided to drive these doors and flaps electrically, what turned out to be very comfortable.

The hydraulic of the docking rings under the sorting box and of the docking funnel of the pre-compactor did not lift and lower steadily. The 3 cylinders of each docking ring or the 4 cylinders of the funnel in the pre-compactor should be synchronized with each other, by having an even weight distribution. It turned out that a synchronal run could not be realized and the docking rings got stuck, so it was necessary to upgrade each docking unit with a flow divider. With this upgrade all docking units moved smoothly and lifts and lowers steadily.

CONCLUSIONS

The drying, sorting and compaction facility improves the whole treatment process by make it more efficient and especially more safe than a treatment with more manual working steps. The facility minimizes the chance of contamination of the personnel by reducing the manual working steps during exposure to contaminated waste as much as reasonably achievable. All other working steps are either with a very low risk of contamination (e.g. sorting with negative pressure inside the sorting box) or eliminated by automation. With the automation of the processes the radiation exposure of the personnel is reduced too and at the sorting positions, the capping and inspection station the exposure is reduced by using a material thickness up to 9 cm where it was needed.

The decision to build up the whole facility in the workshop for a complete commissioning was really a success, because all occurring problems may have been much bigger problems, when they occurred during the installation and commissioning at site and with the customer. Furthermore the personnel has installed the mock-up and therewith it could make a lot of experiences during the installation and commissioning of the whole facility and are well trained for the installation and commissioning on site.