# REDUCTION OF WORKER EXPOSURE DURING ON-STREAM MAINTENANCE IN A PVC PLANT

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## Introduction

The purpose of this brief talk is to highlight a few ways in which worker exposure during on-stream maintenance can be reduced. We have chosen as a background a composite manufacturing facility for polyvinyl chloride.

## Reactors

Reactor cleaning procedures have been the subject of the talks by Fred Krause and John Barr before the break. These procedures are an example of a way to reduce exposures to maintenance workers. There are a few additional procedures which can be highlighted relative to reduction of worker exposure during on-stream maintenance.

One of these procedures involves changing out the double mechanical seal on a reactor agitator shaft. Worker exposure can be minimized during on-stream replacement of the shaft seals by two principal approaches. One is to provide an agitator shaft, coupling, seal and gear drive assembly design which permits supporting of the agitator from outside the reactor during seal replacement. Opening of the reactor to atmosphere or entry by workers in connection with agitator support during seal replacement is thus rendered unnecessary.

The other principal factor in agitator shaft seal changeout is the provision of cartridge type double seal design. The mechanical seal cartridge can be removed as an integral assembly. It is therefore possible to replace the seal cartridge in its entirety with a new or reconditioned cartridge. The worker time at the reactor is minimized. And the cartridge which was removed is simply delivered to the maintenance shop for repair.

The working atmosphere during cartridge removal and replacement is checked by a portable detector and personnel are trained to make use of proper respiratory protection, as required.

Another procedure required for on-stream reactor maintenance is replacement of rupture discs. Let us assume for this example that the disc has begun to leak. Now, the reactor must be taken off the line and made safe relative to replacement of the defective disc. By following well defined regulation procedures, the reactor is made safe so that when the disc assembly flanges are broken there is no pressure under the disc, and therefore no leakage to atmosphere.

Worker time at the reactor can be further reduced by using complete disc assemblies in the design, so that the new disc is already fitted into the replacement disc assembly when the new disc is delivered to the reactor location. As in the case of the mechanical seal cartridge, the disc assembly which was removed is delivered to the shop for fitting with a new disc.

The use of complete disc assemblies also improves the reliability of rupture discs, since seal damage and misfit which can occur during field replacement of a disc are eliminated.

Equipment Evacuation

As prescribed in the regulations, equipment can--under certain circumstances--be safed by connecting it to an evacuation path. An example of this approach will illustrate the procedure.

There are usually two large-size filters in parallel on the discharge of the high capacity pumps which transfer liquid vinyl chloride from storage to process. The filter which is on-stream will eventually need to be taken off the line as the pressure drops through it rises toward the maximum operable value. The clean filter can be valved into service and the fouled filter blocked off. The blocked-out filter can then be vented to the gasholder. This filter can then be filled with displacement water. Final removal of vinyl chloride from this filter prior to opening can be done with reduced worker exposure by connecting the filter to the evacuation system. All of these steps are performed by operators.

On-Stream Flow Totalizer Calibration

Flow totalizers on liquid vinyl chloride batching into reactors can require on-stream maintenance in the form of calibration while the plant is running.

An example of a specific system will show that this on-stream maintenance procedure can be done with reduced worker exposure.

Two totalizer systems are installed in series on the same vinyl chloride liquid flow path. It is assumed that as long as both totalizers are in close agreement, there is proper reliability in their performance. If the totalizer loops develop a discrepancy, they can be checked by running water through them from nitrogen-padded weigh tank at a steady flow-controlled rate. Usually, one totalizer is found to be out of calibration and in need of service. The system is designed so that this totalizer can be by-passed, blocked-off, and removed after proper safing procedures have been carried out. The repaired item can be shop calibrated and reinstalled. Both totalizers (which are now once again in series) can be double-checked by the water weight vs. time method described above.

It may be worthwhile to mention a variation of the system just described. In some installations it is desirable not to put water through the meters. In this instance, vinyl chloride liquid can be run from a VCM weigh tank to and through the meters. The use of liquid VCM makes it unnecessary to run water through the meters to check or calibrate them.

Thermal Expansion Hydraulic Relief Valves for Liquid Vinyl Chloride

There are numerous lines in a PVC plant which carry liquid vinyl chloride. The vinyl chloride liquid can be blocked in so that as the liquid expands in a line because of temperature rise, the pressure tends to go up to undesirable high levels. If this tendency towards higher pressures goes unrelieved the trapped liquid can try to force its way past manual block valve stem packing, control valve stem packing, etc. At worst, the pressure rise could cause sudden failure at an unpredictable location; for example, a line could split open somewhere in the piping run in which the liquid is trapped. Events such as those above could result in worker exposure during on-stream maintenance.

The thermal expansion problem is relieved and avoided by providing hydraulic relief valves at places in the system where trouble from trapped liquid can arise. The discharge from these valves shall always go to a safe and captive part of the system, such as to an upstream surge vessel or to the recovery train.

Pinch Valves

Improvement in design is an on-going activity, which can be pointed up by citing an experience with pinch valves. In the original design the fingers which press on the boots to close off the valve were tearing the boots. Unexpected boot failures could have caused surprise exposure of workers to vapors from unstripped polymer slurry. The pinch valve fingers were modified and lengthened. The improvement in finger design plus routine turn around maintenance reduced a potential onstream source of worker exposure.

Incinerator Maintenance

Incinerator is often the final abatement step prior to atmosphere. Thermal incineration equipment must be capable of running at temperature and space velocity conditions which insure complete reaction of the vinyl chloride component of the vapor stream to hydrogen chloride, water, and $CO_2$.

The incineration step provides a means of taking nonconforming residual vapor streams as feed, and discharging innocuous effluent to the atmosphere. The incineration equipment must incorporate necessary interlocks for safe operation, and must perform on a demand basis with complete reliability at all times. Therefore, two incineration paths are provided in parallel, with each parallel system sized for the full process vapor flow capacity. One incineration equipment line is kept at the ready, while the parallel line is on-stream. This continuous 100% stand-by provision affords a planned and routine scheduling of on-stream maintenance activities with reduced worker exposure. The entire stand-by line can be checked, inspected, maintained, and put back into the at-the-ready condition while the parallel on-stream line is effectively ensuring full reliable compliance with the regulations.

## Rotating Shaft Seals

Rotating shaft seals are required to be double mechanical seals with either pressurizing so that leakage is solely into the process equipment and not to atmosphere, or with ducting so that leaking is to a control system.

The kind of maintenance program which can be followed with excellent results and minimum worker on-stream exposure is typified by the following description. This description is based on actual experience.

In the installation described below, the mechanic or millwright foreman in the plant maintenance group keeps a detailed and comprehensive list called a "mechanical seal survey". This man has an itemized list showing operating time, repair or replacement, and exact specifications for every seal on every pump, agitator, and liquid-ring compressor or vacuum pump in the plant.

There is a principal seal vendor whose representative lives in the area. Through a mutual effort between plant and vendor's representative, and the cooperation of the plant management, a duplicate and up-to-date copy of the mechanical seal survey is kept by the vendor. This situation results in the following two kinds of effective maintenance:

> In the first instance, a seal of size and type used in several locations in the process needs to be replaced promptly. Because it is a commonly used replacement item, it is kept in stock in the plant. A work order and shop requisition procures the seal from stock and the pump is fitted with the seal. Routinely and automatically, the plant man duly notes this new seal usage in the mechanical seal survey, and the vendor's representative is sent a copy of the updated survey. Based on a standing order arrangement with the plant purchasing department, the vendor at once orders a seal to be delivered to the plant to replace the old seal.
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> The seal which was removed can be repaired in the plant shop, or if necessary, returned to the vendor's company for credit value.
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> In the second instance of effective maintenance, a seal which is relatively expensive and is used in limited service application fails, so that it requires a complete replacement in kind. This seal is not in the plant stock. However, it has been determined in

advance by plant and vendor that this seal can be promptly delivered out of the vendor's distribution warehouse at any time on short notice. The plant contacts the vendor, refers him to the specific item on the mechanical seal survey, and the vendor has the new seal on its way in short order.

The following practices described above, and given the excellent current state of mechanical seal technology, the experience factor with seals in the PVC plant is good, and seldom the cause of worker exposure, loss of production, or unwanted emissions. We should note here that experience in general shows a seal life expectancy of up to three years operation, with a statistical average life of about six months without maintenance.

## General

A few general observations will indicate practices which are of proved effectiveness in reducing worker exposure during on-stream maintenance.

1. There is an indoctrination of all involved workers so that they are informed about regulations, precautions, etc., which are specific to working in the PVC plant where exposure must be reduced.

2. As a part of a formal program, workers about to become active in the area are shown how to use the NIOSH approved breathing air appurtenances. This training includes instruction in both the plugin apparatus which permits a man to access breathing air from a permanently piped system, and self-contained apparatus (often called "air packs") which can be worn by a worker who is making his way out of an area on a emergency basis.

3. Well established procedures and parameters established by NIOSH and implemented by OSHA ensure that breathing air qualifying under the "D" quality requirements is available; and that this air can be accessed during normal conditions, and also for prescribed conditions of emergency such as a general power failure.

4. For detailed additional information, one is referred to sources such as 29 CFR Part 1910, amended as of January 1, 1977, and the NIOSH publications of approved equipment listed by manufacturer and exact model number.

5. In conclusion, the most important factor in reducing worker exposure during on-stream maintenance is perhaps also the most obvious factor, that is, planning for most major maintenance work to be performed when the plant is not on-stream.

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DISCUSSION:

MR. THOMAS A. ROY: You mentioned breathing air systems that are available suitable for breathing quality air for, I assume, PVC plants.

MR. RALPH C. BARLEY: I was attempting to highlight some points relative to composite PVC plant, yes.

MR. ROY: Do you know of a way that meets a D or B quality air requirement, I'd like to know about it.

MR. BARLEY: I am not directly connected with those two kinds of processes, but I have a feeling that with all these people here, there is probably someone who can answer that kind of question.

MR. NATHAN W. CLAUSS: In your discussion on totalizers, I believe you said that you installed those in series, and I got the impression that this was to provide some redundancy - I am confused.

MR. BARLEY: This isn't suggested as a practice to be used in each and every installation. However, in one installation it was proven to be useful. There were meters installed in series, and if one of the meters started to drift, it could be blocked out and the other meter would still be performing properly and the blocked out meter could be shop maintenanced and calibrated and put back into service after this, which is a sort of redundancy in the actual practice. After a reconditioned or a new totalizer is put back in, they can again have either the water or the PVC run through them and the calibration can be checked further. Is that what you mean?

MR. CLAUSS: Yes, sir.

MR. BARLEY: There are, obviously, other ways of doing this. These meters have been coming more into prominence, and hopefully, the degree of reliability will come to a point where the redundancy of putting two meters in series, which has been designed by some of our clients, will become unnecessary.

MR. ROY DEITCHMAN: Your emission rate at the valve, how does an individual valve the emission rate vary over time?

DR. B. TOD DELANEY: Before we could get the sample of a line, we like the system to flow for approximately 20 minutes. After 20 minutes checking with the OVA, things usually lined up and we got a constant reading. For each sample we took, we took multiple samples and if the sample were not within a certain percentage of each other, we would then throw that valve over.

MR. JAMES A. GIDEON: Ralph, it seems like much of the state of the art in industrial hygiene is directed toward respirtory protection. I wonder if you also require protective clothing or gloves for use with vinyl chloride and other materials?

MR. BARLEY: That is a good question, and I wasn't really attempting to get into that aspect of it. I was trying to highlight some points about items of equipment maintenance. However, part of the answer to your question is answered in OSHA 29 CFR, Part 1010, relative to protective clothing. Yes, very definitely if a man is about to enter a reactor, he is required to wear protective clothing. Is that what you mean?

MR. GIDEON: I guess the question was do you have any data on permeability of different materials or protective fabrics to various monomers or other chemicals? Would you like to have this kind of data in the design of maintenance procedures?

MR. BARLEY: We surely would like to have it. Your question reminds me of many years ago when I was involved in working with hydrogen fluoride and boron trifluoride. We were told to wear protective clothing, which consisted of coveralls impregnated with paraffin. As soon as the supervisor had their backs turned, we took them off. In my recent observation, there has been tremendous improvement in the comfort and utility of protective clothing.

NIOSH does have a rather comprehensive list of breathing apparatus, and they call out the exact manufacturer, the exact model number, right down to the last detail. Does that help at all?

MR. GIDEON: I guess I am fishing to see whether you see the need for more work in terms of the permeability of different types of protective equipment for specific materials.

MR. BARLEY: Yes. One important thing is to convince the workmen that they need to use this type of item. If a man has been going into a reactor, and a few years ago he was indeed doing it, and either not objecting to the results, or perhaps even enjoying them. It is difficult in some cases to convince the men to use items such as protective clothing. I think that anything that NIOSH could do toward greater comfort and greater ease of donning the clothing would be in order.

MR. JOHN T. TALTY: I know ASTM has recently established a committee on chemical protective clothing that is trying to come up with standardized test procedures for permeability and such. Hopefully, they will be coming up with some useful methods in the future.

MR. BARLEY: In some other industries, they have gone into this double change room concept for workers. They come in from home, must strip down completely, and they're given a complete change of clothes, including underwear and outerwear. On the way back from the plant into the work area, they must go through a shower area. The change room is designed so they cannot avoid it. They dispose of their clothing in the proper receptacle. Until better materials are found, that is one possible way of avoiding the contact problem.

MR. R. NICHOLAS WHEELER: Have you ever run into a case where a volatile material was absorbed out of the air into the clothing?

MR. DONATO R. TELESCA: Can't say I have.

MR. WHEELER: Thank you.

MR. JEREMIAH LYNCH: Ralph, in your two valve system, have you found that it's necessary to have a dead spot about halfway, or do you find that you can have that system working properly without such a dead spot?

MR. BARLEY: You have your two valves that you turn simultaneously. At one point the process is going through them, and in the other operation the sample is being taken.

MR. LYNCH: Do you find it necessary to have a dead spot to prevent cross flow, or is that not necessary to your system?

MR. BARLEY: We have preferred to use a valve that has a dead zone or dead spot in the center, simply because we feel very strongly about making sure there is no possibility that process conditions could be discharged through the sample ports. This is why we feel very strongly about it. We have run into a problem where the people have used the wrong valve and found that there was a discharge during the actual procedure. This is one of the reasons we are very particular about those type of valves. We have had installations where instead, the valves were being operated by two separate air drive actuators. The problem we encountered was that both actuators did not stop the area at the same time. Again, one valve turned faster than the other and allowed some leakage where there were none expected.

MR. DONATO R. TELESCA: The next speaker is Bruce Lovelace, who received his B.S. degree in Chemical Engineering from Webster Polytechnic Institute in Massachusetts. He joined Dow Chemical in 1968 as a Production Engineer involved with the production of styrene and related monomers.

His talk this afternoon will be on the safer design of manual sampling of liquid process streams. There is a large selection of sampling equipment that can be used, and no single piece of equipment is appropriate for all situations. Taking process samples requires an understanding of the hazards of the process material and the circumstances under which it may be sampled; sample size frequency in using special handling procedures and materials of construction. With this information, it is easier to choose a design that meets the criteria to obtain the desired process sample, and protect the individual during this procedure.

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