UNDERWATER FUEL HANDLING EQUIPMENT MAINTENANCE

VERIFICATION OF DESIGN ASSUMPTIONS, SPECIFIC PROBLEMS AND TOOLS, CASE STUDY

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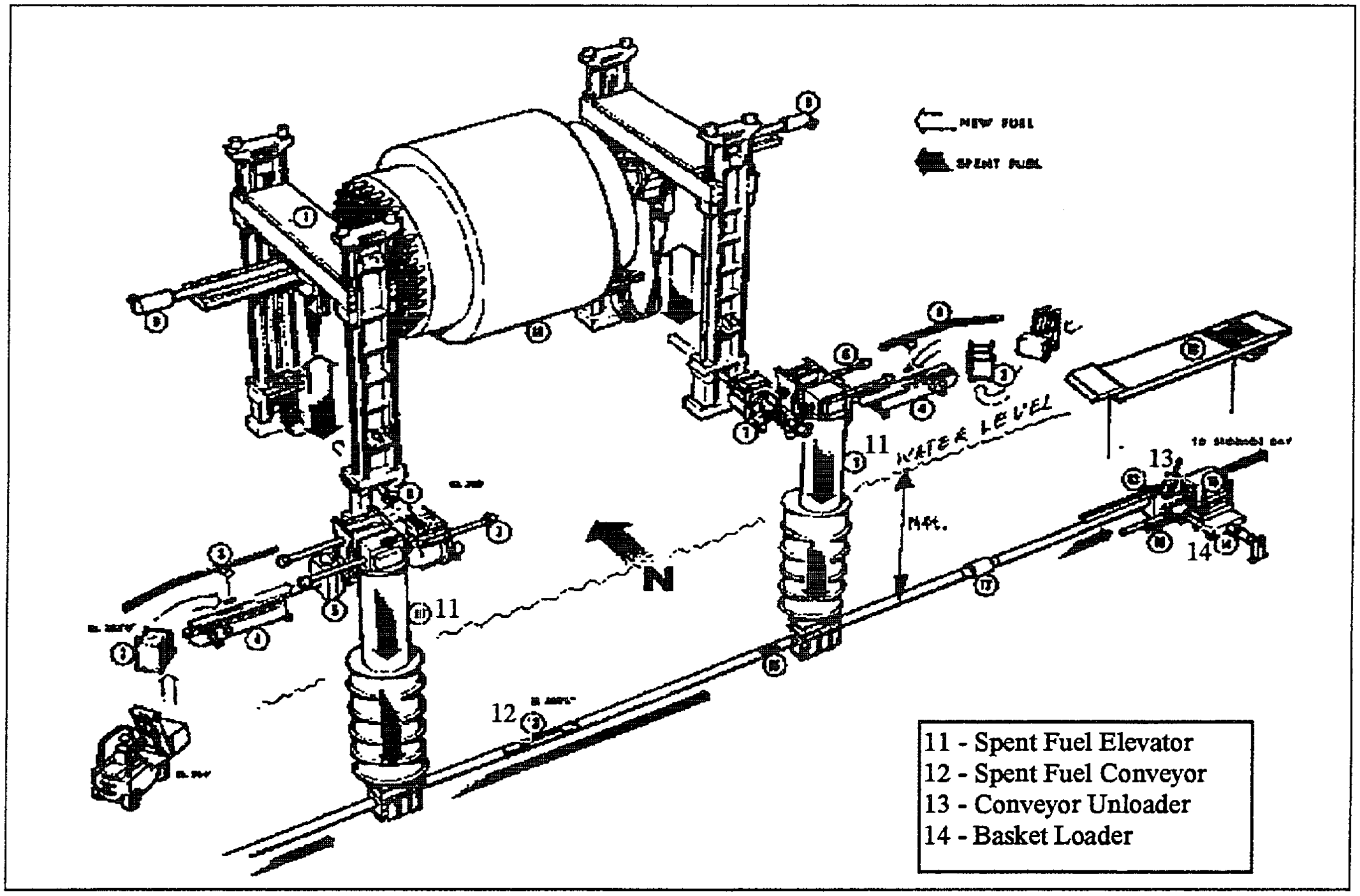
The majority of CANDU Fuel Transfer System equipment at Pickering is located under 14 Ft. of water, as dictated by the containment and shielding requirements. Such arrangement, however, creates specific problems with equipment maintenance (especially after 20 years of service).

The General Design Assumption for maintenance of this equipment was very simple – Receiving Bay, all Elevator Shafts and Conveyor will be drained, and required maintenance/repair will be carried out like on any other machinery in the nuclear island. Too good to be true? – Yes. After over twenty years of operation and many unsuccessful attempts to follow this idea (to drain the Conveyor or Receiving Bay) the conclusion is clear "THE ASSUMPTION" is a great idea, however, not attainable.

Since you can not remove the water, the only other option is to go under the water (and face the consequences) – that's exactly what was done! Easier said than done. Interesting question – what has prevented us from draining the Conveyor, Elevator, or Receiving Bay?

The major obstacle was (and still is) – presence of damaged fuel pencils (from the early days of opera-



Fuel Handling system with marked up underwater equipment tion) hidden in the inaccessible areas of equipment. In addition to this, there was no provision in design to isolate and drain section of the Conveyor or Elevators of single unit. Expectation to have two units (1 & 2 or 3 & 4) shut down for maintenance, for prolonged time simultaneously, remains an unreal wishful thinking. Presently engineers from Pickering Fuel Handling, together with AECL are working on the project to allow isolation and draining of the section of the Conveyor or single Elevator (the dream of the maintenance people).

Another very important aspect, worthy of the designer's consideration, is to avoid all partially enclosed spaces in the underwater equipment design to eliminate potential for hidden damaged fuel pieces (damaged fuel does happen). The same applies to equipment that is to be removed from the water for maintenance (example – Basket Loader).

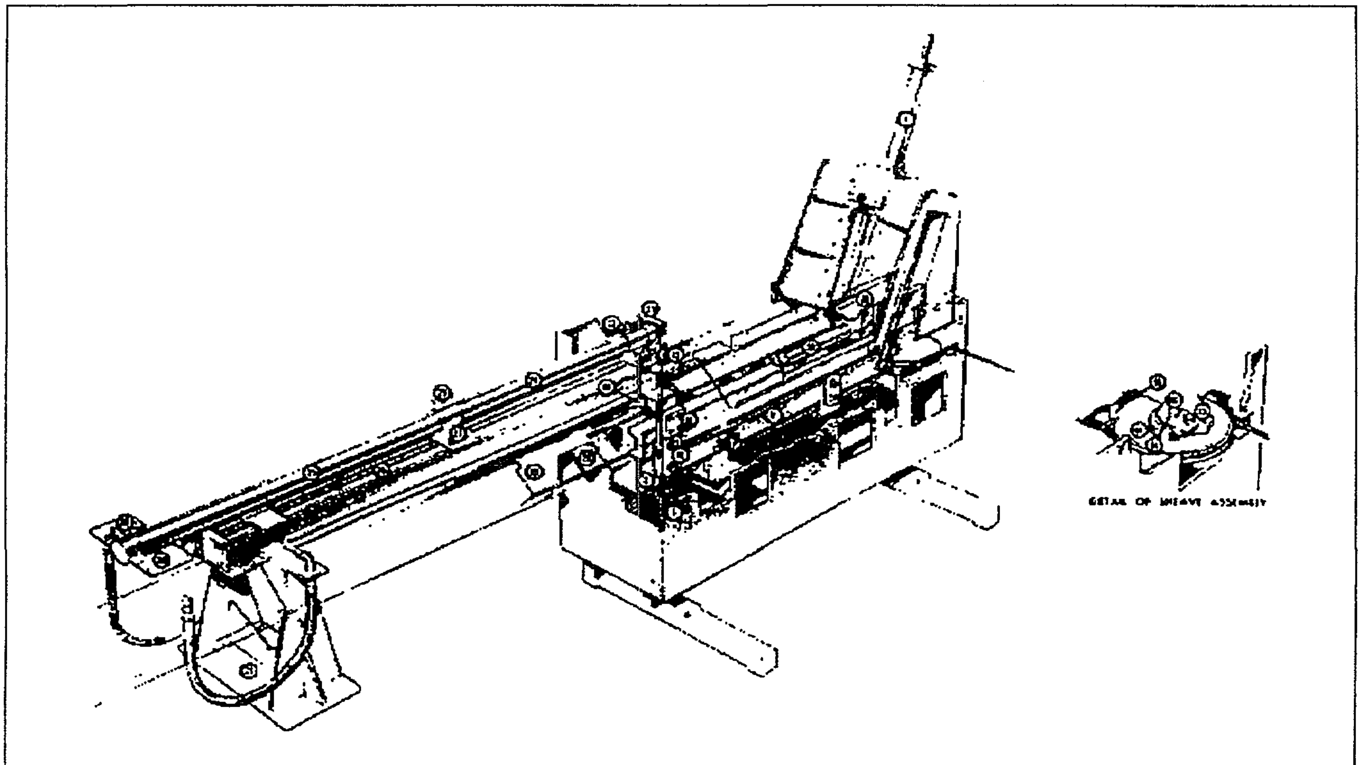
Underwater Fuel Transfer Equipment such as: Elevator, Conveyor, and Conveyor Unloader design philosophy are entirely based on the assumption of draining and isolation of the Conveyor and Receiving Bay – i.e. there are no provision to make underwater maintenance easier, or sometimes even possible. The only piece of equipment designed to be removed from the Receiving Bay for maintenance is a Basket Loader. Full overhaul of the unit 012 Basket Loader (first time after 20 years of service) was just recently successfully completed. No doubt designers and manufacturer deserve credit (without mentioning a few minor problems).

One of the very challenging tasks in our Underwater Fuel Handling Equipment maintenance history in Pickering Station was to replace seized directional pulley/shaft assembly on both Conveyor Unloaders (012 and 034). Operation of two 540 MW units was at stake when this pulley was seized.

Fortunately, it was revealed that operation of the Conveyor with seized pulley is possible for limited time and under modified operational conditions (conveyor cable tension was lowered and cable was sliding on the stationary pulley – cutting deeper and deeper the pulley material). The time was running out.

Initially, the original design assumption (draining the Receiving Bay and working on "dry equipment"), was considered, but again this time, it was recognized as not achievable (for previously mentioned reasons).

The other option was to do the work through 14 Ft. of water, with remote tools and T.V. camera. Thus the special tools were designed, fabricated and tested on the dry "mock-up" to perform this task. Before starting underwater pulley /shaft assembly removal, the task analysis was performed and a few questions



Spent fuel conveyor unloader with detail of seized pulley/shaft assembly.

were raised : • What force is required to remove seized shaft/bearings assembly? • What are the consequences of breaking the shaft puller while shaft is being partially removed? • What is the puller strength? • What is the max. torque to be applied to the puller without damaging the tool (or shaft)?

Well, the expected consequences of tool failure during the job were very serious – no fuelling available on two units for prolonged period of time (until some new ideas are developed and successfully implemented).

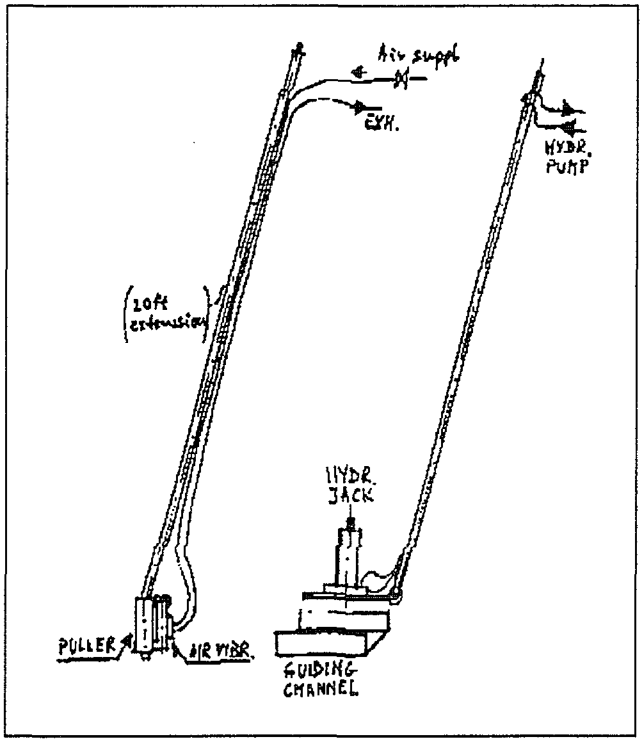
To make sure that the tool limitations (max. torque the puller is operated and max. vertical pulling force) were known, a destructive test of the tool was performed. When the results from dry rehearsal and destructive testing were obtained, the assumption was made, that it will be safe to operate puller up to 80% of the max. torque (max. torque was defined as a tool damaging torque) – i.e. safety margin was established at 20%.

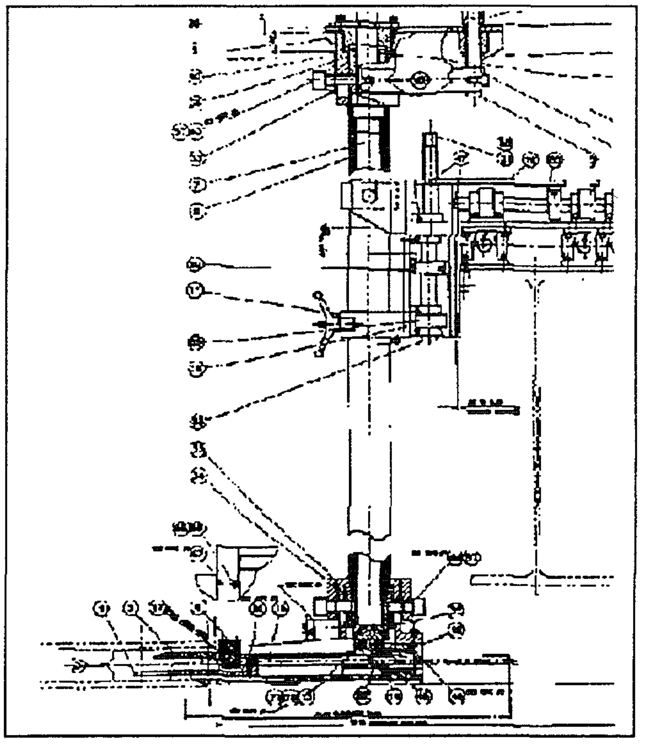
After all these preparations, the replacement of seized shaft/pulley assembly on unit 034 (Conveyor Unloader serving Units #3 and #4) was successfully completed, however, the tool was brought up to its limit (max. torque applied).

Attempt to replace the same seized shaft/pulley assembly. On the other unit (012), using the "battle proven" set of tools – failed, the shaft was seized beyond the tool capability. New, more powerful tools were required. In addition to the existing set of tools, two interesting new tools were developed (in-house) and later proven successful, namely underwater hydraulic jack with guiding mechanism, and adjustable frequency air vibrator (attached to the puller).

The successful completion of the job this time was mainly credited to the vibrator action.

As both tools, mechanical puller and guided hydraulic jack were able to produce considerable static force (limited only by strength of the Conveyor Unloader structure), the seized shaft did not even move, until the vibrator was started. The "miracle of vibration" resulted in the seized shaft being removed within seconds. The vibrator was the typical pneumatic piston unit with the large scope of adjustable frequency ranging from 3.000 v.p.m. to 11.000 v.p.m. (as a function of air flow & pressure ranging from 20 p.s.i. to 80 p.s.i.). Our understanding is, that while the vibrator air supply valve was slowly open and vibrator ran through full range of frequency – at some point it passed through the resonance range, which triggered movement of the seized shaft. Note: The shaft/pulley assembly was originally equipped with two ball-bearings (s.s. – water lubricated), which failed almost simultaneously on both units after about twenty years of service. Design modification was implemented and ball-bearings were replaced with special bushings. The shaft was also modified,





Special tools: puller with the vibrator; guided hydraulic jack; pulley removal tool.

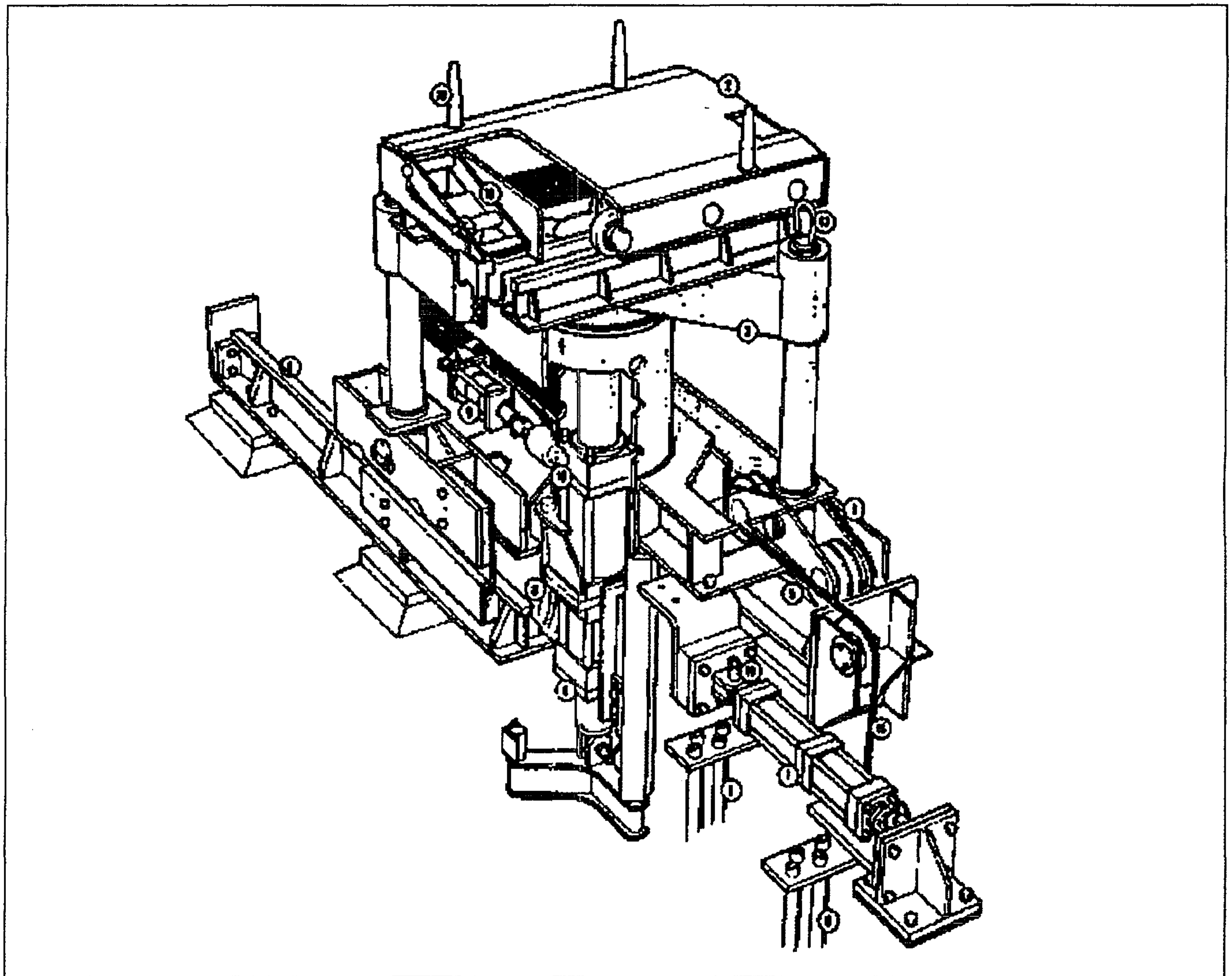
to allow easy removal when replacement is required.

Human Factor. The major difficulty of this job was no doubt working through 14 Ft. of water and being able to see the shaft and pulley assembly only through underwater T.V. camera, and under limited angle. Guiding the tools (hydraulic jack and shaft puller/vibrator) to the position of proper engagement required great deal of skill and patience. Highly skilled and dedicated team of mechanics is required for such a task, to ensure the success, and "at the first time". We have had failed attempts in the past as a result of underestimating the human factor.

Other underwater work, worthy of a few words are the removal of the Basket Loader from the Receiving Bay for first major overhaul after twenty years of service (just recently completed).

The challenge was a job never done before, and damaged fuel hidden inside the Basket Loader structure (creating potential for very high radiation field, when B.L. is lifted from the water).

Deteriorating performance of the unit, namely sluggish movement of the hydraulic cylinders was the main reason for the B.L. overhaul. Twenty years of service, without even replacing the hydraulic cylinders' seals was considered close to the limit. Underwater high pressure water lancing was chosen as the primary method of B.L. decontamination, and removal of fuel elements from the B.L. surfaces. Unit was lifted from the track closer to the surface (still fully submerged) and treated with high pressure water, then very slowly moved through the water surface (water lancing continued) with the gamma meters pointed at it and continuously reading the radiation field.



Basket Loader

Radiation fields measured from work distance were not higher than ten to twenty mRem/HR (well within the limits), few "hot spots" up to 5 Rem (on contact) were also found. Surface contamination level at some spots was as high as 50.000C.P.M. After further field decontamination, the B.L. was transported to our decontamination facility before disassembly. About one thousand man-hours was spent on the job (removal of B.L. from the bay, decontamination, complete overhaul, testing and reinstallation), and total of 360 mRem dose was committed.

Considering that the B.L. was in service for twenty years in a very harsh environment (water, radiation, dust, and other impurities) – the wear of moving part was much lower than expected.

Obviously the main reason for sluggish hydraulic was wear and deterioration of the cylinder rubber seals; however , metal surfaces of the cylinders and pistons were found in ideal condition.

Other underwater challenges on the horizon for Pickering "A" Station:

1. Isolation of section of the Fuel Transfer Conveyor and Elevator, to allow draining of the single Elevator and Conveyor for maintenance purpose (project in co-operation with AECL).
2. Inspection of the inside of Fuel Transfer Conveyor tube, using T.V. camera travelling on the cart.
3. Fuel transfer Conveyor Unloader – removal from the bay, complete overhaul and reinstallation (Conveyor. Unloader was designed as "nonremovable", and was supposed to be serviced after dewatering the Receiving Bay).
4. Renewed attempt to perform Receiving Bays decontamination and subsequent draining (as an alternative to #3 above).

GENERAL NOTES:

Maintenance of underwater Fuel Transfer equipment at Pickering "A" (the oldest station in our CANDU family) presents the biggest challenge to mechanics for a few reasons:

First, each single piece of equipment serves two generating units, which means in case of defect – double losses on production, or two units shut down simultaneously for planned maintenance.

Second, the requirement for underwater maintenance was not anticipated at the design stage, which multiplies the level of difficulty, and creates requirement for developing special tools for each work.

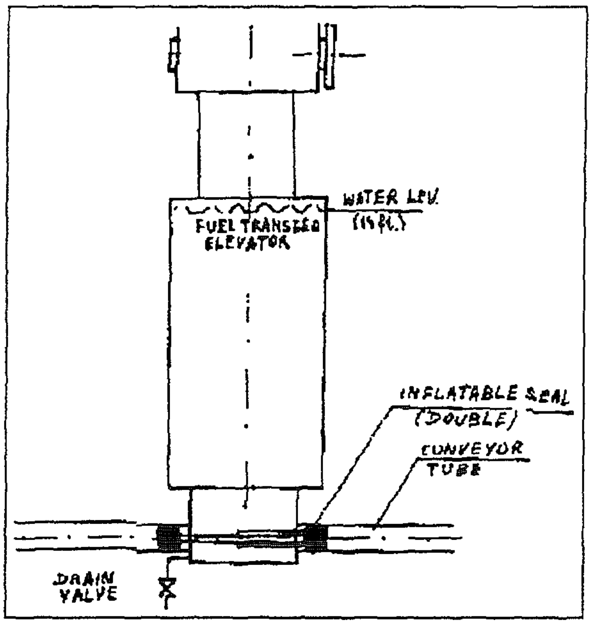
Third, lack of contingency option (design provisions for equipment removal, or for underwater service) to the great idea of Receiving Bays dewatering.

Removal of the damaged fuel from the Receiving Bays and decontamination of submerged equipment is also part of the problem.

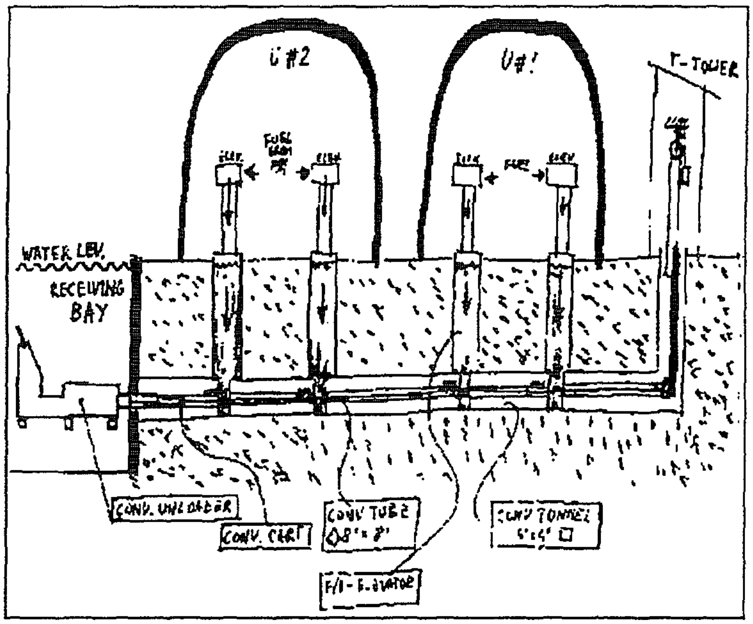
FINAL STATEMENT:

The purpose of this presentation is to share our experience with the designers, operators, maintenance mechanics, and technical personnel of the other CANDU generating stations.

"What is life worth without the challenge??????" (Not much).



F/T conveyor and elevator-isolation/draining



F/T conveyor system – schematic