It is two a.m. and Mr. Dave Rhodes, Head of the Fluid Sealing Technology Unit at Atomic Energy of Canada Limited's (AECL) Chalk River Laboratories has been up all night, his only sustenance a bag of peanuts in the last eighteen hours. He is in full radiation protective gear and ready to tackle whatever is thrown at him because the potential consequences for the nuclear power plant that he has been called to are severe.

All in a day's work at AECL in Cana

By Jemin Mahida

Mr. Rhodes's role involves solving problems in often difficult and harsh conditions, in a race against the clock. Obviously safety in a nuclear power plant is crucial, and is of highest priority while minimizing the cost of being off line. The pump needs to function, the seal needs to work, and the plant needs to be up and running, fast. Mr. Rhodes shares some of his experiences with us.

AECL is a fully integrated nuclear technology and services company providing services to nuclear utilities worldwide. AECL is also the designer and developer of the CANDU® (Canada Deuterium Uranium) reactor technology. The Fluid Sealing Technology Unit within AECL provides round the clock site support to nuclear power plants and in particular to those with pumps using AECL modified seals.

AECL mechanics rebuilding a BWR reactor cleanup pump at the Chalk River Laboratories. This pump is highly radioactive and must be handled with care. Without reliable operation of this pump, the reactor cooling system chemistry would slowly deviate from specification forcing a plant shutdown.

Inspection and maintenance services

Mr. Rhodes explains: "Fluid sealing has often demanded more than its fair share of attention in nuclear power plants. However, to achieve the improved plant reliability that the industry now expects requires simultaneous attention to many other areas. As well as our fluid sealing group, other groups within AECL help customers with areas such as remote inspection, replacement of highly radioactive components inside the reactor, instrumentation and control, corrosion and other chemistry problems, and major refurbishment projects. Our pump seal customers are generally quite competent and skilled, but appreciate assistance with training and when dealing with unusual situations."

AECL's main pump seal customers are likely to be system engineers responsible for running the plant, maintenance, and dealing with problems. In their aim to minimize problems and glean advice, customers put great emphasis on ensuring that, when a problem occurs, they

can get someone on the phone or on site immediately. Mr. Rhodes adds: "We have twenty people in the sealing group and a larger pool of mechanical engineers in the next organizational unit. When there's a problem one or two of them are sent out."

Pump seals

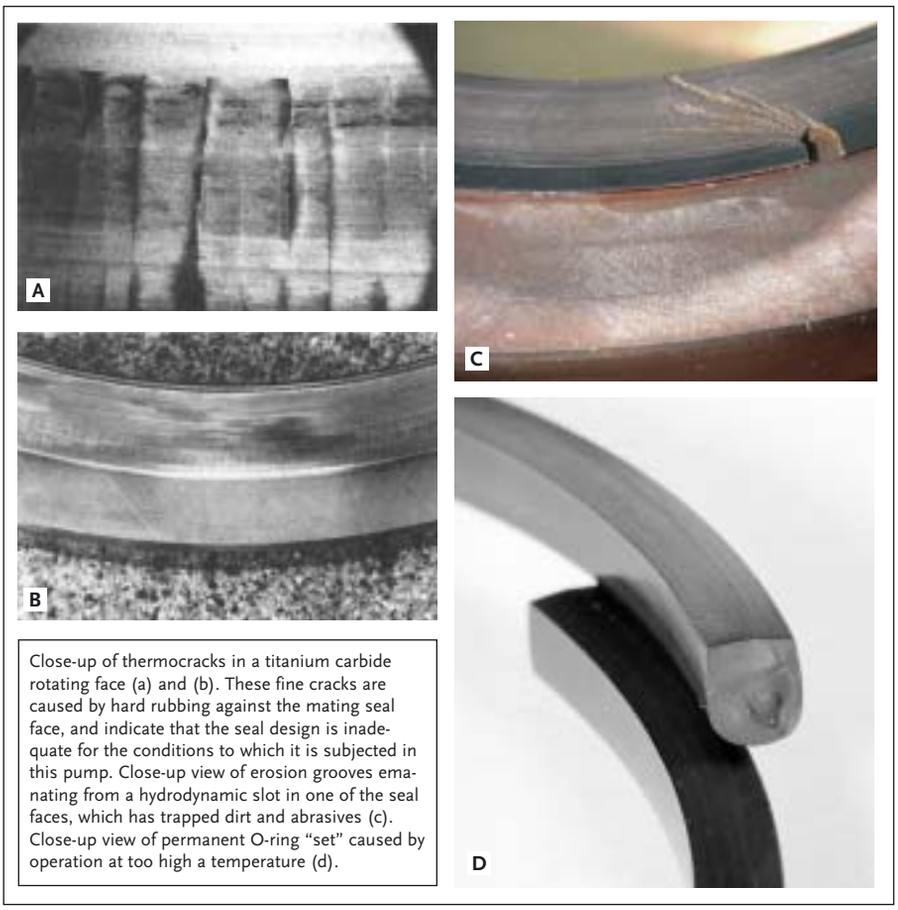
Mr. Rhodes' area of expertise includes pump seals, their reliability and duration of service. The right seals can effectively save customers millions of dollars in outage time and person-rem (the average individual radiation dose multiplied by the number of people exposed). As fluid sealing technology experts, Mr. Rhodes and his colleagues provide customers with a range of comprehensive seal services and long-term support. Mr. Rhodes explains why pump manufacturers or sealing suppliers do not always provide seals that meet AECL's stringent requirements: "Some seals provided by pump manufacturers in the past have been unreliable, or haven't kept pace with what is now possible. Also, as a plant ages, the operating conditions for pumps and seals may become more severe. In the early 70s, we designed a seal for a pump that was having problems in our own test facility and that's how it all started. Since then we've encountered many examples of plants that want to improve the lifespan of their seals. Examples include the Grand Gulf, Duane Arnold, Nine Mile Point One, and Oyster Creek Boiling Water Reactor (BWR) plants in the United States. We solved their problems by designing a new seal that's been working great ever since. Some of our seals can run for up to four normal outages (or six-to-eight years) which is a major improvement in seal lifetime."

Mr. Rhodes continues: "The bulk of seals we produce are sold to CANDU and BWR nuclear power plants, in Canada, the US, and Europe. While the pumps are basically the same, the processes may differ. AECL is currently designing new Advanced CANDU Reactors (ACRs) and our pump section is talking to us about designing a super seal or at least improving specifications by buying better pumps. The pumps used will be bought from external manufacturers and our pump section decides what type of pump and which seal it will contain. Our department will check to see if the proposed seal meets AECL requirements or whether we can provide a more appropriate seal. Although the ACRs have not yet been built they will require seals with, for example, a six to eight year lifespan and will be far more advanced than those currently available."

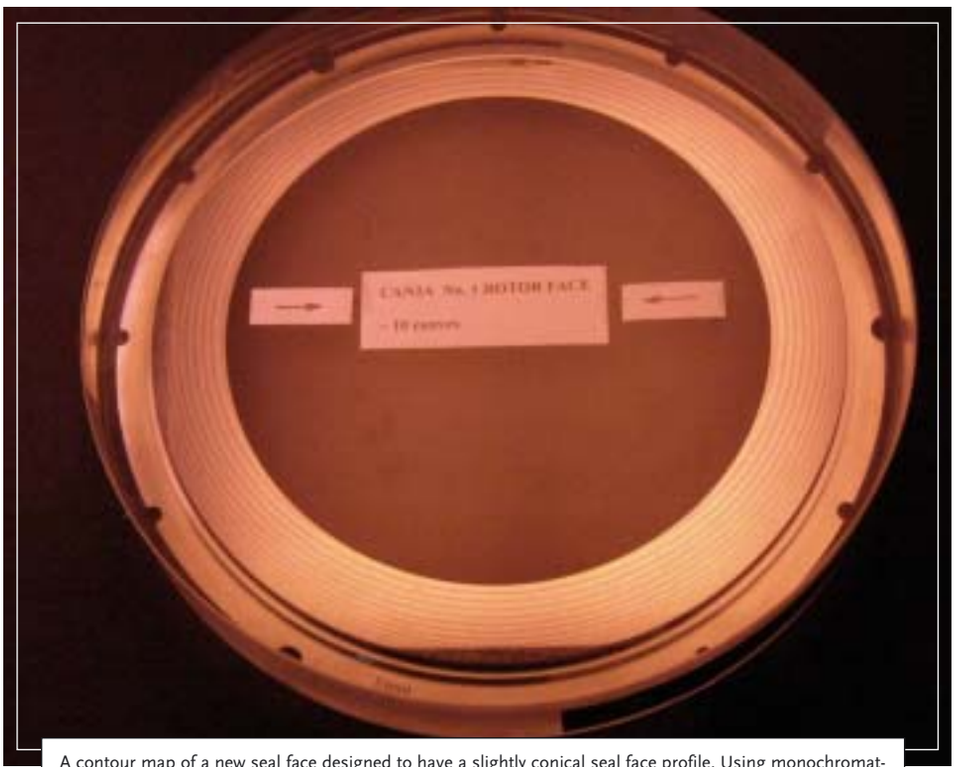
ECC strainers/Sump performance

In addition to testing, inspecting, repairing and maintaining pump seals Mr. Rhodes and his team are also involved in the designing and building of special strainers for water and mechanical hardware used in Emergency Core Cooling Systems (ECCs) in nuclear power stations.

Mr. Rhodes explains that: "We have done this for the last six years. The unique Finned Strainer® was developed as AECL's solution to ECC strainer clogging concerns. The strainer incorporates porous fins moderately close together so >>



Close-up of thermocracks in a titanium carbide rotating face (a) and (b). These fine cracks are caused by hard rubbing against the mating seal face, and indicate that the seal design is inadequate for the conditions to which it is subjected in this pump. Close-up view of erosion grooves emanating from a hydrodynamic slot in one of the seal faces, which has trapped dirt and abrasives (c). Close-up view of permanent O-ring "set" caused by operation at too high a temperature (d).



A contour map of a new seal face designed to have a slightly conical seal face profile. Using monochromatic light through an optical flat (an extremely flat piece of quartz glass) an interference pattern is produced showing the flatness of the face. The convexity (i.e., the difference in height of the inside of the face relative to the outside) is roughly 9 lightbands, or 4 µm. After a seal has been run, the face is usually roughened slightly and the lightband patterns are no longer visible.

the amount of filtration area in a given volume is multiplied. Attached to a common header, it can be sized and configured to suit a wide range of conditions. In, for example, an accident involving a loss of coolant where a large pipe breaks and water from the reactor cooling system drains into the basement of the reactor building, the emergency core cooling system uses suction pumps to suck water from the basement, and pumps it back into the reactor cooling system. A lot of debris can be generated from a pipe break, so a large strainer in the basement is used to filter this waste out so it doesn't get pumped back into the reactor. Ten such strainers are currently being made with a partner in France and thirteen have been supplied to various CANDU plants around the world."

When manufacturing seals, AECL staff decide which parts should be manufactured in their own shops and which should be subcontracted out. When all the individual pump seal parts come back to them, they conduct a final inspection and do the final lapping and assembly, if necessary, before sending them on to the customer. However, strainers, for CANDU plants (in Canada or abroad) are made in Canada on their own site. Mr. Rhodes continues: "Clients come to us to work out which pump seal they will need, how it will be made, and tested. In terms of the number of pump seals we produce per year we won't put the top manufacturers out of business but we do produce a replacement article of exceptionally high quality. Since we can't force manufacturers to put our seals into their pumps we have to convince end users that our seals are superior. We therefore have to know a lot about the original manufacturers' products and how to handle them. For example, we designed a seal for a shutdown cooling pump in CANDU

About AECL

Name:	Atomic Energy of Canada Limited (AECL)
Founded:	1952
No. of employees:	3200
Services:	Nuclear services, R&D support, design and engineering, construction management, specialized technology and waste management and decommissioning in support of CANDU reactor products. (inspection services, valve services, surface science / metallography, steam generator services, life cycle management, hot cell facilities)
Products:	Power reactors CANDU 6 (700 MWe class), and ACR1000 (Advanced CANDU Reactor, 1100 MWclass), pump seals, ECC strainers, and MACSTOR safe spent fuel storage systems

reactors and a reactor water cleanup pump in BWR reactors. The seal in a reactor water cleanup pump is often poorly cooled, running near to the boiling point. Its location in the circuit also makes it susceptible to dirt contamination. We designed a seal with two hard faces, running carbide against carbide, thus eliminating the dirt problem. The result is a seal with a lifetime in the range of seven years, as opposed to two to seven months."

Support

Generally, the kind of support a customer would prefer is for situations they can plan for. Planned support includes training, as Mr. Rhodes explains: "We train mechanics onsite at AECL or at the customer's facility. We instruct in not only how to build or assemble seal parts, but also how to inspect parts, how to inspect flatness using optical flats, and how to lap parts in case they need to be touched up. We also teach mechanics how to look at a used seal and properly examine it. When a seal has operated for a long time deterioration is inevitable. It is important to look carefully and learn from this. And then there are the crisis situations that obviously don't fit under planned support."

In addition, AECL also offers:

- R&D to address fluid sealing problems
- custom seal design and supply for new or retrofit applications
- detailed examination of contaminated parts in extensive in-house laboratory facilities
- failure analysis of pump seals and elastomers in the field
- field or laboratory refurbishment and re-build of seals including complete cartridges
- stress, temperature, lubrication and deflection analysis of seals, including elastomers
- choosing and retrofitting commercially available valve packing products to station valves

Other planned pump seal services offered by AECL include routine seal change outs. Since CANDU plants have several units on one site they have ample opportunity to practice seal changes. Mr. Rhodes explains that: "Some single-unit plants like us to be present when they are changing a seal, either to do it for them, or to oversee the seal change. This will usually have been planned for, a few months in advance. Some aspects of assembly training are generally applicable, like cleanliness, care (how to handle elastomer seals), post-service inspection, and the lapping touch up. However, a different aptitude or skill is required for post-service inspection. Imagine you are in a nuclear power plant where a seal is contaminated. You are in full protective gear with gloves and a mask on, it's hot, and the clock is ticking. A Health Physicist (HP) – safety expert who's job it is to minimize your radiation exposure – is breathing down your neck. Communication can be poor because of background noise and protective clothing, and sometimes we can only observe. The real challenge for an inspector is to instill a slow, careful, methodical approach in the work crew's attitude. Corners cannot be cut, and evidence must not be destroyed by rushing. If you see something untoward, stop! Try to figure out why it's happening – unusual indentations, wear marks, dirt, etc. It might not be possible to answer all these questions but they must be recorded and analyzed in the hope that something falls into place."

Sometimes less obvious factors lie at the root cause of problems, and the need for a speedy response often results in, what Mr. Rhodes calls, his adventures: "The cost of hiring a private jet to get an expert to a plant in time pales into insignificance when you consider the potential cost of power plant downtime in thousands of dollars per minute. It is of paramount importance to a customer that, when necessary, we are able to move mountains for them." ■

About Dave Rhodes

Mr Rhodes has a Bachelor's degree in Mechanical Engineering from the University of Toronto, and a Master's in Mechanical Engineering from the Massachusetts Institute of Technology. He joined Atomic Energy of Canada Limited's Chalk River Laboratories in 1981, where he heads the Fluid Sealing Technology Unit. He has led development and retrofit projects for various nuclear equipment in Canada, USA and Europe, including new main coolant pump seals for boiling water reactor and CANDU® nuclear power stations, and new emergency core cooling strainers at various CANDU and pressurized water reactor stations.