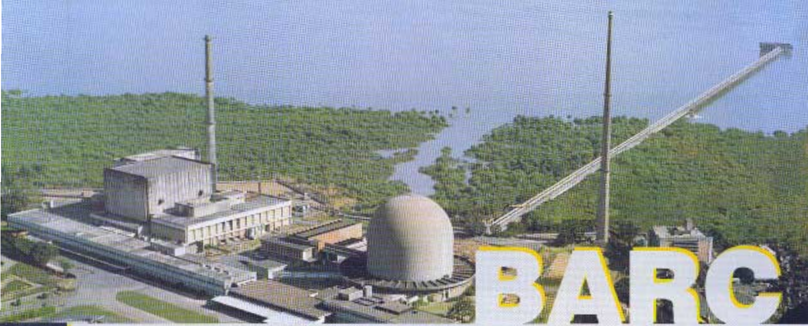

BARC NEWSLETTER

No.185, June 1999

INSTRUMENTED PIPELINE INSPECTION GAUGE (IPIG) FOR INDIAN OIL CORPORATION LTD.

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Introduction

There are eleven thousand kilometres of oil pipelines existing in India for transporting crude and oil products from different places. Indian Oil Corporation Ltd. (IOC) owns approximately 6000 kms of these pipelines of sizes ranging from eight inches to twenty-eight inches in diameter. These pipelines sometimes pass through thickly populated areas carrying highly inflammable and costly products. Regular monitoring of the condition of these pipelines is necessary to ensure public health and safety.

IOC had approached BARC for the development of an on-line pipe inspection gauge for their pipelines. An MOU was signed between BARC and IOC on April 17, 1995 for the development of an Instrumented Pipeline Inspection Gauge (IPIG) for their 12" pipelines within a period of 30 months.

The IPIG works on the principle of saturating the carbon steel oil pipe section with high magnetic flux and monitoring the leakage flux on the inner surface of the pipeline with the help of 64 Hall sensors over its full periphery. The IPIG consists of a Magnetic Module, a Data Acquisition System (DAS) Module, a Battery Module, Residual Sensors with DASII Module and a PIG Locator Module. Three odometers are also attached to record the movement of IPIG.

Contents

Fig. 1 : Launching of IPIG at wet test loop at Faridabad.

EDITORIAL

Transportation of crude oil and other hazardous oil products safely through thickly populated areas is a problem faced by the oil refining companies. The present issue carries a feature article reporting on how BARC successfully developed and tested a pipeline inspection gauge for IOC in a record 30 months' period.

BARC has recently developed lightweight maintenance-free heat pipes and plates for transporting large amounts of heat at low temperature differences. The performance of these heat pipes and plates have been found to be of international standard.

On June 5, 1999, the World Environment Day, Rajasthan Atomic Power Station (RAPS) had the unique distinction of bagging the Golden Peacock Environment Management Award 1999 as a Runner Up, for outstanding achievement in the field of Environment Management. The award is instituted by World Environment Foundation. RAPS has made the entire DAE family proud by securing the award.

Change is a part of life, and it adds colour to life. BARC Newsletter *has been given a face-lift from the May issue onwards.*

Contributions in the form of articles and brief reports are invited for publication in BARC Newsletter. *Please enclose glossy prints of illustrations with your write-up. Sending your material in a floppy using MS Word/Wordstar software will greatly help us.*

A polyurethane cup mounted on the IPIG seals the pipe, and the pressure of the oil flowing through these pipelines give the required propelling force for its movement. Generally the front cups are sealing cups and the other cups are supporting cups.

In this assignment, it was essential to study the leakage flux patterns around the notches and pits taking into consideration material characteristics, acquire signals generated due to faults and filter them to get noise-free signals. In order to achieve sufficient expertise in these areas, a number of experimental facilities, such as static test rig, rotary test rig, dry pull-through rig and wet test loop were planned and built at Faridabad. The results from these experimental facilities have given a good amount of information, which proved very useful for building the first prototype IPIG, which has been tested in the wet test loop at IOC in Faridabad (Fig. 1).

Magnetic Module

There are eight segments in the Magnetic module, which cover almost ninety percent of the total periphery of the pipe, as shown in Fig. 2 and 3. Each segment consists of two strong Neodymium Iron Boron magnets of size 70mm x 70mm x 10mm, magnetized along the thickness, and placed on two sides of the Backing Iron. There are two sets of brushes on both the sides which not only offer low reluctance path to the flux entering the pipe wall, but also clean the wax deposited during operation, since the deposition of any

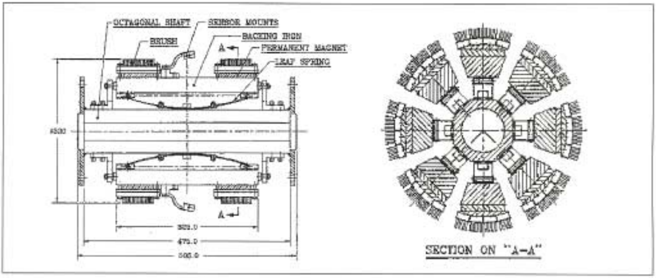


Fig. 2 : Magnetic module assembly (sketch)

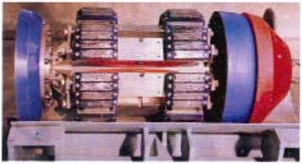


Fig. 3 : Actual magnetic module assembly

material on the pipe surface increases the gap between pipe surface and the sensor, affecting the fault signal. Spring loaded polyurethane sensor arms with hall sensors are in the central portion of the backing iron. The directions of magnetisation of the permanent magnets are such that the mmf of each gets added and this helps in driving the pipe wall into saturation. Each assembly is mounted on leaf springs so that the magnetic module can negotiate the weld protrusions, bends and tees, etc.

Data Acquisition System Module

The heart of the data acquisition system is a 486-based single board computer (SBC). A "multiplexer card" and an analogue data acquisition card acquire magnetic flux leakage signal from 64 sensors. The SBC then transfers the data to a hard disk, qualified for high level of shock and vibration. The electronics and the hard disk are housed in a pressure tight vessel on anti-vibration mounts. The electrical connections are taken through connectors specially designed to withstand very high pressure. All the 64 sensors are sampled for every 2mm travel of PIG. The cue for acquisition is taken from the fastest moving odometer at any time.

Battery Module

This module houses the power supply for the instrument. It has two battery packs for the two DAS units. Each battery pack is connected to a DC-to-DC converter which feeds the electronics of DAS unit. It also gives supply to active and residual sensors. Ampere hour of each pack is 60 at rated drainage. With our present requirement of DAS and taking into consideration the efficiency of the DC-to-DC converter, the lifetime of each battery pack is expected to be 40 hours. The battery module also houses a control circuitry which gets input from the odometers and converts them into signal acceptable for DAS unit. In case the PIG stops for a long time, the DC-to-DC converters are switched off. This saves the unnecessary drainage of the battery when the data acquisition is not required during the period when the IPIG is not moving.

PIG Locator Module

This module consists of an electromagnetic transmitter which after energising emits low frequency electro-magnetic radiations which can be picked up by a pistol type antenna at a distance upto 10 metres. One can locate the IPIG during its travel along the length of pipe with the help of this antenna.

Data Analysis

The data is analysed off-line by a defect inspection software. The raw data is filtered in scale-space plane to eliminate noise due to sensor bounce, unequal lift-off, non-uniform pipe thickness, etc. The 'denoised' signal is used for automatic detection of peaks due to metal loss defects and an image is formed by using a set of rules. The gray-scaled/coloured image is used for visual inspection of surface and depth extent of a defect. Fig. 12 shows a typical image developed from the data obtained from a run in wet evaluation facility. The long vertical line spanning the full periphery of the pipe is the air gap at the flange joint. Other gray patches are due to welding at the cut edges and created defects.

Finite Element Method (FEM)

Since close form solutions for the computation of leakage flux around the faults in the pipe are not possible in this case due to nonlinearity of the B-H characteristics of the pipe material, the leakage flux distribution around pits and notches can be calculated quite satisfactorily by FEM technique using commercially available packages. The samples of pipe materials of

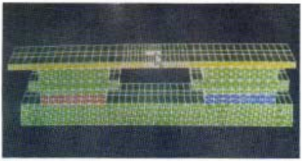


Fig. 4 : 3-D FEM model of magnetic module sub-assembly using MAGNET software

different grades have been procured from IOC and the torroid shaped core of this material have been fabricated for the generation of actual B-H curve, since the leakage flux pattern is heavily dependent on the B-H characteristics of pipe material. Using the actual B-H characteristics of these pipe materials, 3D FEM models (Fig. 4) have been generated and the flux density distribution around the notch has been theoretically established and verified experimentally (Fig. 5).

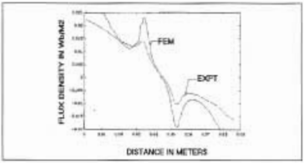


Fig. 5 : Comparison of actual and computed flux density level

Static Test Rig

Static Test Rig (Fig. 6) was made to study experimentally the leakage flux levels around a test section. The test section is made out of the actual pipe obtained from IOC. The dimension of the test section is 320mm (l) x 125mm (w). The plates used for the test section are 6 mm and 9 mm thick. One sub-assembly of the magnetic module is fixed on the table. The sub-assembly consists of backing iron, brushes, test section and two NdFeB permanent magnets . The test section is placed over the brushes. Hall sensors are used to detect

Fig. 6 : Static test rig

the leakage flux near the test section. The hall sensors are potted in a module and the potted module is fixed on a sensor arm. The sensor arms are mounted on a moving x-y table. The lead screw of the x-y table is coupled to a D.C motor. The entire area over the test section can be scanned using this method. Limit switches are installed on both sides of the x-y table.

Table 1

EXPERIMENTAL TEST RESULTS OF STATIC TEST RIG

Plate size 325 mm x 125 mm x 6 mm

Sl. No.	Notch size (mm)	Radial F.D. P-P Gauss	Span (mm)
1.	18 x 18 x 1	128	18
2.	18 x 18 x 2	230	18
3.	18 x 18 x 3	235	18
4.	24 x 24 x 2	235	24
5.	24 x 24 x 3	295	24
6.	30 x 30 x 1	145	30
7.	30 x 30 x 2	285	30
8.	30 x 30 x 3	400	30
9.	36 x 36 x 1	130	36
10.	36 x 36 x 3	420	36
11.	24 x 24 x 1 + 18 x 18 x 2	135	24
12.	24 x 24 x 2 + 18 x 18 x 3	220	24
13.	30 x 30 x 1 + 24 x 24 x 2	200	30
14.	30 x 30 x 2 + 24 x 24 x 3	310	30
15.	36 x 36 x 1 + 30 x 30 x 2	200	36
16.	36 x 36 x 1 + 30 x 30 x 2 + 24 x 24 x 3	225	36

Plate size 325mm x 125mm x 9mm

Sl. No.	Notch size (mm)	Radial F.D. P-P Gauss	Span (mm)
1.	18 x 18 x 1	59	18
2.	24 x 24 x 1	65	24
3.	30 x 30 x 1	81	30

The distance travelled by the sensors along the length of the test section is 100 mm. The analog signals obtained from the hall sensors are then converted into digital signals using a 12-bit ADC card. The signals are then stored on a personal computer. The leakage flux magnitude depends on the size of the notch. The depth and axial length of the fault are very important parameters which affect the peak gauss level. The distance between the positive and negative peaks indicate the axial length of the fault. The depth of the fault can be computed from the flux density levels of the peaks and the axial length of the fault. Various faults on 6mm and 9mm thick plates have been created and tested on static test rig thus generating a good amount of data bank (Table 1).

Rotary Test Rig

It is not possible to simulate the effect of velocity on the fault signals on static test rig, which is quite important. Hence a simplified rotating drum test rig (Fig. 7) has been fabricated to study the

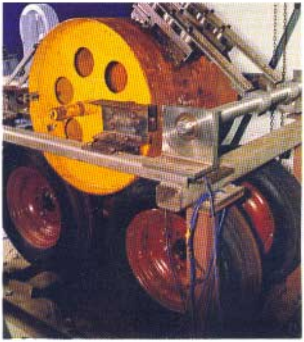


Fig. 7 : Rotary test rig

effect of velocity on fault signals in the laboratory. Here the dynamic testing of detectors and its repeatability can also be checked. The set-up consists of a short section of pipe of the same material as that of the actual pipe but of much bigger diameter, supported with axes horizontally, on a set of car tyres. One sub-

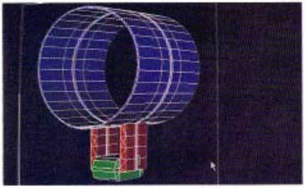


Fig. 8 : FEM model of drum with electromagnet

assembly of the magnetic module was specially designed and fabricated using NdFeB magnets and brushes to suit the dimensions of rotating drum. This sub-assembly along with the sensors and sensor mounts was placed on the outside of the rotating drum, thus completing the magnetic circuit through the drum. It may be noted that the faults on the inner side are created with difficulty, but could be detected. These are corresponding to the far side defects in actual pipe. The drum is rotated by drive wheels mounted on two axles from a variable speed 5-hp DC motor through a reduction gear box. The front axle is coupled directly to the output shaft of the gear box. The rear axle is dummy. Complete Finite Element modelling of the existing drum has been done using the actual B-H curve of the pipe material (Fig. 8). Known faults were created on the outer surface of the drum and the results were recorded on Data Acquisition System. The results obtained through FEM modelling for various sizes of the faults are given in Table 2 and 3. This includes the radial and circumferential components of the leakage flux density computed on a contour 2 mm away from the pipe surface.

Table 2

EXPERIMENTAL TEST RESULTS OF ROTARY TEST RIG

Length and Width of the defect (mm)	Depths of the defect (mm)	Peak to Peak (Gauss)	Span (mm)
12 x 12	2	13.7	13
	3	14.3	13
	4	20.1	13
18 x 18	2	17.1	20
	3	17.7	17
	4	26.6	19

Table 3

LEAKAGE FLUX ANALYSIS OF ROTARY TEST RIG USING FEM

Sl. No.	NOTCH SIZE (MM)	RADIAL F.D.		CIRCUM.F.D.	
		P-P G	SPAN (MM)	P-K G	SPAN (MM)
1mm DEEP NOTCHES					
1.	12 x 12	56	12	22	12
2.	12 x 18	58	18	18	18
3.	12 x 24	51	24	16	24
4.	12 x 30	50	30	15	30
5.	12 x 36	50	36	13	36
2mm DEEP NOTCHES					
1.	12 x 12	120	12	67	12
2.	12 x 18	110	18	42	18
3.	12 x 24	102	24	27	24
4.	12 x 30	109	30	40	30
5.	12 x 36	109	36	25	36
3mm DEEP NOTCHES					
1.	12 x 12	160	12	70	12
2.	12 x 18	170	18	52	18
3.	12 x 24	150	24	53	24
4.	12 x 30	160	30	45	30
5.	12 x 36	160	36	70	36
4mm DEEP NOTCHES					
1.	12 x 12	210	12	100	12
2.	12 x 18	215	18	75	18
3.	12 x 24	180	24	65	24
4.	12 x 30	180	30	52	30
5.	12 x 36	180	36	40	36

Linear Pull Through Rig

Linear pull through rig (Fig. 9) was commissioned in November 1997 at BARC for dry evaluation of mechanical components of prototype IPIG and to generate database for characterisation of defects. The rig consists of 25m of straight length of pipe formed by joining eight flange-joined sections. These pipe sections were retrieved from 12-inch commercial pipeline of IOC.

There is a semi-cylindrical SS launching/retrieving tray connected to a reducer at either end of the rig. A motor-gear box assembly winches the PIG through the linear pull through rig with the help of a steel rope. The prototype PIG made about 50 successful runs in linear pull through rig. All the features in the rig, e.g., reducers (entry and exit), flange joints, weld affected zones near the flange joints, support pillars, edges of the cut section with defects and straps to hold the cut section, could be

Fig. 9 : Linear pull through rig

identified from signal analysis of repeated runs. A set of metal loss defects was created on a cut section of pipe by machining. The data from the runs were downloaded from the on-board computer to permanent storage. The PIG recorded coherent and repeatable data in several runs over the same defects. Signal parameters that discriminate defects of different sizes are presented in Table 4.

Table 4

EXPERIMENTAL TEST RESULTS OF LINEAR PULL THROUGH RIG

Length and Width of the defect (mm)	Depths of the defect (mm)	Peak to Peak (Gauss)	Span (mm)
24 X 24	2	176	45
	3	224	40
	4	496	26
	5	576	26
18 X18	2	128	24
	3	176	20
	5	288	24

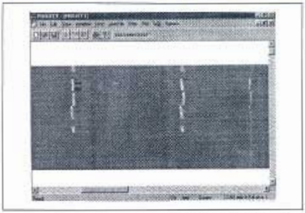


Fig. 10 : Gray image showing cut section and defects in linear pull through rig

The gray image of the pipe section is given in Fig. 10, showing cut edges and defects. The sizes of the defects were chosen in such a way that the database could be used to characterise unknown defects in actual runs. After a large number of runs in the straight length, a 5-d bend was put at one end of the rig to test the ability to negotiate the bend with water pressure. The magnetic module could negotiate the 5-d bend with water pressure of 2 kg/cm^2. Successful runs in the straight dry length and through the bend with fluid pressure gave us required confidence to start experiments in the wet evaluation facility.

Faults in linear pull through rig were created in a pipe section of dimension 550mm X 500mm X 6mm. Discrepancies in some readings of span can be attributed to the jerky motion of the PIG through rig as a result of winching without oil.

Wet Evaluation Facility

Wet evaluation facility was set up at R&D Centre, IOC, Faridabad, (Fig. 11) to assess the performance of instrumented PIG in real field conditions. The rig has a 14-inch launching/receiving barrel at either end. The PIG is launched in the barrel by pulling it from the front with a rope. Then the launching and retrieving gates are closed and the PIG travels through the rig with the flow of oil. Several configurations of PIG (starting from dummy with a gauge plate to a configuration close to instrumented PIG with magnet and dummy sections) were launched in steps, to test the mechanical passage of the PIG through 120 m length of pipe. The instrumented PIG was launched once the confidence regarding clean passage of the PIG was high. Four runs of the instrumented PIG have been taken without

Fig. 11 : Wet test loop at IOC, Faridabad

created defects on any pipe section, including the first run on December 2, 1998. The runs have ensured that all the sections of the PIG negotiate 6-d mitred bends and pass through girth weld joints, flange joints, barred tees and a motor-operated valve (MOV) without any damage to components. The pressure sealing of vessels and electrical connectors were also tested in these runs and were found to be all right.

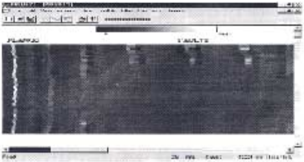


Fig 12 : Gray image showing a flange and defects in wet evaluation facility

Table 5
EXPERIMENTAL TEST RESULTS OF WET EVALUATION FACILITY

Length and Width of the defect (mm)	Depths of the defect (mm)	Peak to Peak (Gauss)	Span (mm)
18 X 18	2	67	18
	4	119	16
24 X 24	2	104	28
	4	173	22
36 X 36	2	127	34
	4	217	40
36 X 24	2	98	36
	4	173	36
45 X 45	2	140	44
	4	161	46

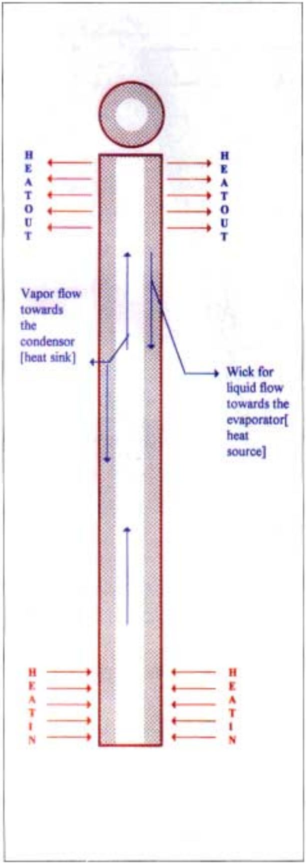
The typical signatures at mitred bends, welds, flanges, supports, tees, MOV and other pipe features were acquired by the data acquisition system and were identified later from the off-line analysis of the signal. The distance measurements by odometers and signature of pipe features were validated in repeated runs. In every run, the IPIG detected all the features it has travelled through. After acquiring data from healthy pipe, three spools were replaced with sections having metal loss defects of known sizes created by machining. Table 5 shows typical parameter values of MFL signal near these defects. The gray image of the pipe section is given in Fig. 12 showing a flange and defects. As in linear pull through rig, the sizes of the created defects are derived from the required accuracy and by following ASME B-31G, which is the defect assessment criterion for carbon steel pipes.

Conclusion

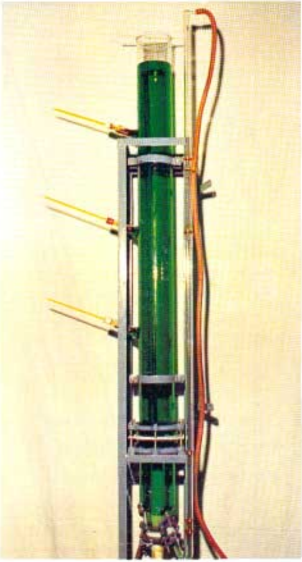
The development of IPIG Model which has been tested in the wet test loop at IOC R&D centre, Faridabad, has been completed in record time of approximately 30 months. This has given very good and useful information for the development of commercial version of the instrument. This unit will be tested at Barauni-Patna line of IOC very soon and the final unit with required modifications would be manufactured and handed over to IOC for further testing in other pipelines.

BARC DEVELOPS HEAT PIPES AND HEAT PLATES OF INTERNATIONAL QUALITY

Prototype Development Section of Chemical Engineering and Technology Group, BARC, has developed various configurations of heat pipes and heat plates, whose performance in heat transfer is in conformity with the international standards. Heat pipes are two phase counter current heat transfer devices. They transfer heat very rapidly from one end to another in the form of latent heat of vaporization and condensation of the working fluid. Heat pipes employ capillary action of wicks for transporting liquid condensate towards the evaporator and, hence, are capable of transporting heat efficiently in any orientation (even against gravity), while, thermosyphons which are also two phase devices depend upon gravity for condensate transport and hence can transport heat vertically upward only.



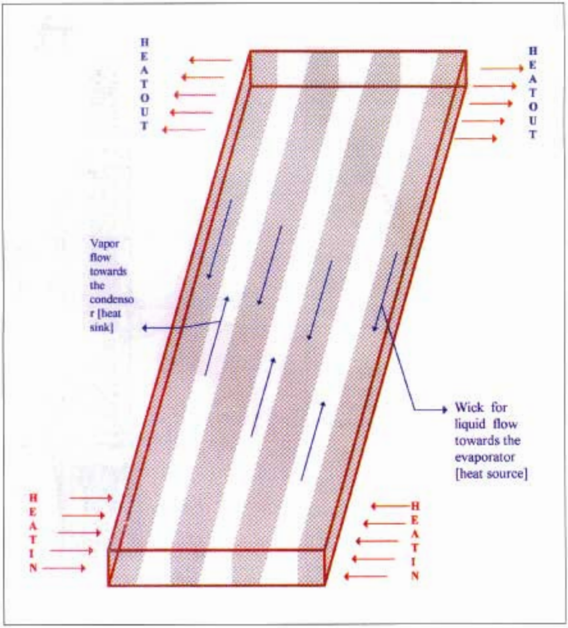
Functional sketch of heat pipe



Wick treatment apparatus

Heat pipes developed in BARC use copper and stainless steel as materials of construction for wicks and casing, and water as working fluid. Water is an attractive choice for working fluid because of its high latent heat of vaporisation. But, its poor wettability necessitates special treatment of wicks to enhance capillary transport of working fluid return. Special wick treatment methods, coupled with precise inventory control of working fluid have been developed for attaining higher heat transport capability.

Configurations developed and tested in BARC are straight tubular heat pipe structures extending upto 1300 mm, bent tubular structure extending upto 300 mm and heat plates of size 300mm(l) X 80mm(b) X 10mm(t).



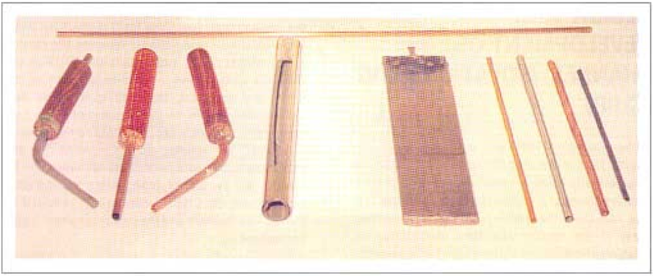
Functional sketch of heat plate

Performance of a typical heat pipe is as follows :

- Material of casing : Copper
- Material of wick : Copper
- Dimensions : 9.5 mm .& 300mm length
- Mesh size : 100 mesh
- Working fluid : Pure outgassed water
- Temperature of Evaporator : 98 C
- Temperature of Condenser : 45 - 50 C
- Condenser is 90 mm above evaporator
- Heat transporting capacity : >150 watts

Possible applications include :

- Imparting uniformity of temperature in large enclosures /ovens.
- Precooling for dehumidification and simultaneous reheating in Air Conditioning systems resulting in higher energy savings.



Heat pipe/plate construction components

- High efficiency heat sinks in electrical industry.
- Waste heat recovery systems.
- Passive cooling system for decay heat removal from radioactive waste solution and vitrified waste cannisters.
- Concentration of nuclear waste solution.
- Solar heat collection and transport systems.
- Diffusion of hot spots in chemical and electrical industries.
- Elimination of thermal stresses in pipe joints.
- Thermal control of satellites.

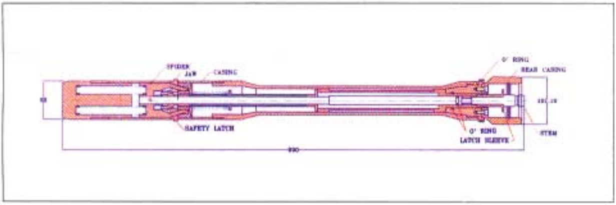
Special properties of heat pipes which make them an attractive choice for aforesaid applications are :

- There is no motive power required in form of pumps etc. to increase turbulence as in case of conventional Heat Exchangers.
- Ability to transport large amount of heat at low temperature differences.
- Temperature gradient along heat pipe surface is negligible.
- Heat pipes/plates are maintenance free for many decades.
- Working fluid of heat pipe does not come in direct physical contact with the source or sink fluids.
- Heat pipes are significantly lightweight.
- High heat transfer capacity prevents any hot spots/ zones.
- It can be made using different combination of working fluid, wick and pipe materials as well as in different shapes according to the application requirements.
- Response is very fast.
- High axial heat flux imparts capability to remove large amount of heat from small aperture/openings.

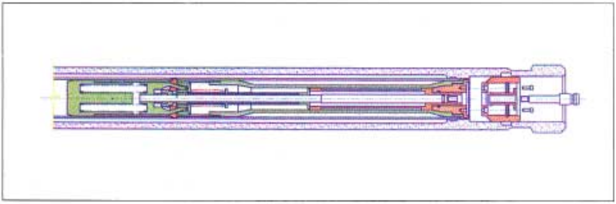
DESIGN AND DEVELOPMENT OF CHANNEL ISOLATION PLUG (CHIP)

While operating PHWRs, leaks occur in the sealing face of the end fitting where the sealing plug normally helps to retain the integrity of PHT pressure boundary. Although lapping of the seal face can solve the problem, it involves shutting down of the reactor and then de-fuelling, ice plugging and draining of the problematic channel, consuming considerable reactor down time and manrem expenditure. To reduce this problem, Channel Isolation Plug (CHIP) has been designed and developed. In the design of the CHIP, safety latch similar to normal plug has been used to prevent accidental unlatching. The CHIP isolates the end fitting seal face from PHT pressure boundary and allows free flow through the channel. The installation of the CHIP is done by the fuelling machine. The fuelling machine visits the problematic end fitting, removes the sealing and shielding plugs, and installs the CHIP in the shielding plug groove. After installation of the CHIP and leak test, the fuelling machine gets unclamped. Some of the components like rare casing and fasteners are manually removed from the CHIP to create approach route to the problematic seal face, where maintenance can be carried out by special tools. After maintenance work is over, the CHIP is normalised, removed by the fuelling machine and the coolant channel is also normalised.

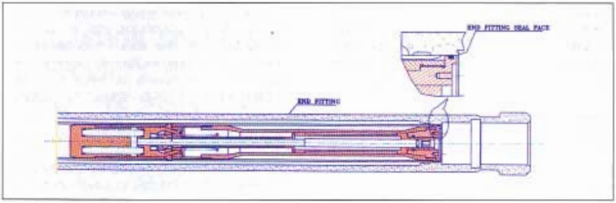
A prototype of the CHIP has been fabricated and tested successfully. The first of its kind was delivered to NAPS and was used successfully for repairing J-04 channel of NAPS Unit-1. Subsequently, MAPS has requested for two numbers of CHIP to suit their reactor. The plug has been modified for RAPS/MAPS type of reactors and delivered to the site.



Channel isolation plug (CHIP) for end fitting seal face lapping



The component rear casing is being removed



End fitting seal face is opened and ready for lapping

Development of Channel Isolation Plug will greatly help in maintaining the problematic leaky seal face of end fitting without draining, drying and isolation of the channel. It also makes possible to quickly lap the seal face. This kind of plug is required by all the operating PHWRs. (Ref. BARC Report No. BARC/1998/I/16).

WORLD ENVIRONMENT DAY CELEBRATED

Dr Anil Kakodkar, Director, BARC, planting a tree sapling

On the eve of the World Environment Day on June 4, 1999, Landscape and Cosmetic Maintenance Section, BARC, organised a programme of planting trees as well as the inauguration of Polyhouses and Shadenet houses which were built inhouse at the Nursery of BARC. The polyhouses and shadenet houses, where roses, gerberas and indoor plants are grown, were inaugurated by Dr Anil Kakodkar, Director, BARC. Tree saplings of Polyalthia longifolia (Asupala) were also planted by Dr Anil Kakodkar, Mr S. Narendra, Principal Advisor, Planning Commission, New Delhi, Dr U. C. Mishra, Director, Health, Safety & Environment Group, BARC, Mr R. Ganesan, Controller, BARC, and other senior officers of BARC.

Interior view of the Polyhouse, showing cultivation of roses and gerberas

The polyhouse/shadenet house is the latest concept in rearing plants and growing flowers, which not only provides conducive environment for plants but also gives a good working atmosphere during all the seasons of the year for the staff. The quality of flowers/plants grown in a polyhouse is better and the yield is also 5 or 6 times that in field condition. Four small polyhouse/shadenet houses were erected in the Nursery recently by using re-cycled and re-used materials available in Trombay.

The greenery preserved and created in Trombay is serving as green lung to the suburbs of Mumbai. BARC is highly conscious about the environment and its protection right from its inception by its founder, Dr Homi J. Bhabha.

GOLDEN PEACOCK ENVIRONMENT MANAGEMENT AWARD PRESENTED TO RAPS

Consequent to the efforts put in by Environment Survey and Micrometeorological Laboratories (ESML) of Health Physics Division, BARC, in monitoring the radiation doses received by the members of public from Rajasthan Atomic Power Station (RAPS) and continuously providing data to RAPS about the radiation levels in the environment, the latter was adjudged as the Runner Up for exemplary achievement in the field of Environment Management and received the Golden Peacock Environment Award 1999 on June 5, the World Environment Day. The award was presented by Mr Suresh P. Prabhu, Honourable Minister of Environment and Forest, Govt. of India, during the World Conference on Environment Management 1999 at New Delhi. The award, instituted by World Environment Foundation, is distributed to large, medium and small scale industries for excellence in environment management. This award has been conferred on Nuclear Industry for the first time and RAPS, the oldest Indian Pressurised Heavy Water Reactor (PHWR) is the proud recipient of the award.

The environment surveillance around RAPS is conducted by ESML. The primary objective of environmental monitoring is to assess the radiation doses received by the members of public due to RAPS operations and to demonstrate compliance with the dose limits set by Atomic Energy Regulatory Board (AERB). The monitoring programme is being continued by ESML since 1973 to assess the radiological impact of RAPS operations on the local environment.

The radiation dose to the members of public due to the releases from the station is evaluated on annual basis. Annually about 4000 samples of atmospheric, terrestrial and acquatic origin were processed to evaluate the radiation doses to the members of public at different distances.

The contribution of radiation dose due to RAPS releases during the past three decades is observed to be very small. The computation of the doses due to intake of radionuclides by the population around the plant upto 30 km is done by measurement of concentrations of radionuclide in air, water, vegetables, cereals, milk, meat, fish, egg, etc. The data collected on environmental surveillance reveals that in any of the years since 1973, the total dose to the members of the public at RAPS fence post (1.6 km) was less than 10% of the limit of 1 mSv set by ICRP/AERB for the public.

Furthermore, RAPS - 2 had undergone the challenging task of en-mass coolant channel replacement during 1996-98. This major job, that may be said as the heart transplantation of the power reactor which is unprecedented in the Indian nuclear power programme, was undertaken for the first time in our counry. The task was completed successfully in a safe and economic manner and well before the time schedule. The en-mass coolant channel replacement campaign composed of removal and safe disposal of the exposed coolant tubes and their replacement with fresh ones. Although tremendous amount of radioactivity was handled during the process, the radiation exposure to occupational workers and the members of public were observed to be well below the prescribed limits. This was achieved by adopting good house keeping and safe practices for radiation protection at each step. The education/ awareness and training about radiation protection also helped in reducing the environmental discharges.

The award to RAPS this year is a tribute to the eco-friendliness of our nuclear installations.

WORKSHOP ON SAFETY OF RADIATION SOURCES AND SECURITY OF RADIOACTIVE MATERIALS

A workshop on Safety of Radiation Sources and Security of Radioactive Materials was jointly organised by the Radiological Physics and Advisory Division, BARC and Atomic Energy Regulatory Board at Mumbai during April 14-15, 1999. Apart from scientists of BARC, DAE and AERB, the participants were from various organizations all over India representing the Central and State Governments such as Airport Authorities, Port Trusts of India, Intelligence Bureau, Excise and Customs, Border Security Force, Coast Guard and Civil Defence College.

In his welcome address, Dr U.C. Mishra, Director, Health, Safety and Environment Group, BARC, pointed out the importance of co-operation among the various Government units in handling the problems arising out of threat to security of sources. The workshop was inaugurated by Prof. P. Rama Rao, Chairman, AERB, who described specific instances of problems arising from loss of sources. Mr P.N. Malhotra, Member-Secretary, Central Board of Excise and Customs, New Delhi, speaking at the inauguration, described the global nature of the problem. The inauguration was followed by Technical sessions spread over two days which included a total of fifteen lectures apart from a demonstration.

The workshop included many discussions which highlighted the specific problem areas of each of the handling agencies. Several questions about radiological hazards were answered during the workshop. Participants expressed that unfounded fear for radiation was removed in the discussions during the workshop. Further, the responsibilities of the various participating agencies were clearly delineated. All the participants expressed satisfaction over the conduct and utility of the workshop as it identified the role of each participant in the event of any problem challenging the safety of sources and security of radioactive material. Some desired that such workshops should be conducted periodically to refresh and update the participants on the developments. It was unanimously agreed that the outcome of the workshop would be a training programme which should be organized for the various personnel identified by the participants.

WORLD NUCLEAR STATUS IN 1998

A total of 434 nuclear power plants were operating around the world in 1998, based on data reported to the International Atomic Energy Agency (IAEA) Power Reactor Information System (PRIS). During 1998, four nuclear power plants representing 2958 MW(e) net electric capacity were connected to the grid, three in the Republic of Korea and one in the Slovak Republic. Additionally, construction of four new nuclear reactors started in 1998 two in China (plus one in Taiwan, China) and one in Japan, bringing the total number of nuclear reactors reported as being under construction to 36.

The countries with more than 40% reliance on nuclear power in 1998 were: Lithuania, 77.2%; France, 75.8%; Belgium, 55.2%; Sweden, 45.8%; Ukraine, 45.4%; Slovak Republic, 43.8%; Bulgaria, 41.5%; Republic of Korea, 41.4% and Switzerland, 41.1%. In total, 18 countries relied upon nuclear power plants to supply at least a quarter of their total electricity needs.

A table showing the electricity supplied by nuclear power reactors in 1998 and the respective percentage of electricity produced by nuclear energy is given overleaf.

NUCLEAR POWER REACTORS IN OPERATION AND UNDER CONSTRUCTION AT THE END OF 1998

Country	Reactors in operation		Reactors under construction		Nuclear electricity supplied in 1998	
	No. of Units	Total MW (e)	No. of Units	Total MW (e)	TW (e). h	% of Total
Argentina	2	935	1	692	6.93	10.04
Armenia	1	376			1.42	24.69
Belgium	7	5712			43.89	55.16
Brazil	1	626	1	1229	3.27	1.08
Bulgaria	6	3538			15.49	41.50
Canada	14	9998			67.50	12.44
China	3	2167	6	4220	13.46	1.16
Czech Rep.	4	1648	2	1824	12.35	20.50
Finland	4	2656			20.98	27.44
France	58	61653	1	1450	368.40	75.77
Germany	20	22282			145.20	28.29
Hungary	4	1729			13.12	35.62
India	10	1695	4	808	10.15	2.51
Iran			2	2111		
Japan	53	43691	2	1863	306.94	35.86
Kazakhstan	1	70			0.09	0.18
Korea, Rep. of	15	12340	3	2550	85.19	41.39
Lithuania	2	2370			12.29	77.21
Mexico	2	1308			8.83	5.41
Netherlands	1	449			3.59	4.13
Pakistan	1	125	1	300	0.34	0.65
Romania	1	650	1	650	4.90	10.35
Russia	29	19843	4	3375	95.38	13.08
South Africa	2	1842			13.58	7.25
Slovak Rep.	5	2020	3	1164	11.39	43.80
Slovenia	1	632			4.79	38.33
Spain	9	7377			56.68	31.66
Sweden	12	10040			70.00	45.75
Switzerland	5	3079			24.37	41.07
UK	35	12968			91.14	27.09
Ukraine	16	13765	4	3800	70.64	45.42
USA	104	96423			673.70	18.69
Total*	434	348891	36	27536	2291.41	

**Note : The total includes 6 units in operation and 1 unit under construction in Taiwan, China.*

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