Counterfeit/obsolete Equipment and Nuclear Safety issues of VVER-1000 Reactors at Kudankulam, India

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Abstract

Counterfeit equipment is becoming a major threat to nuclear safety globally. The Kudankulam Nuclear Power Plant (KKNPP) in India housing two VVER-1000 reactors, imported from Russia is being delayed because of counterfiet, substandard and obsolete equitpment. The polar crane, the limb of the reactor, is defective as its hoisting capacity is less than 80% of its nameplate capacity. The crane is used for installing the equipment inside the reactor building and also for removing spent fuel. The contract said that there will be no weld in the beltline of the reactor pressure vessel (RPV). The received vessels have two circumferential welds on the beltline. RPV, the heart of the reactor is irreplaceable and hence determines the life of the reactor. RPV and polar crane are safety grade equipment. The core-damage frequency (CDF) of the reactor in the contract was 10^{-7} reactor-years, while the supplied reactor has a CDF of 10^{-5} reactor-years. Two units of generator transformers were received as damaged and these were dismantled and reassembled at the site. This paper finds evidences of the unethical practises of sale and use of obsolete and counterfeit reactor equipment and discusses the global catastrophic risks with reference to the international nuclear safety standards.

Keywords: Counterfeit reactor equipment, Nuclear Safety, Global Catastrophic Risk, Reactor Pressure Vessel, Core Damage Frequency, Radiological Disaster, Kudankulam Nuclear Power Plant, VVER-1000, obsolete reactor equipment.

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1 Introduction

The Kudankulam Nuclear Power Project (KKNPP) is a joint venture by the Russian company Atomstroyexport (ASE) and the Nuclear Power Corporation of India Ltd (NPCIL). Under the agreements signed in 1988 and 1998, Russia supplied the equipment and drawings, while India has to undertake civil constructions and commissioning of 2x1000 MW(e) pressurized water reactors. The first pour of concrete for the first reactor building was done in March 2002 and the reactor was to be commissioned 69 months later in December 2007. As of 1 May 2013, the project has been delayed by 64 months. This study indicates that the main cause of the delay in project implementation is the defects in the equipment supplied by ASE. Since these also include safety grade equipment, there is also a potential for accident. Here we summarize our case study of three over dimensional equipment which are difficult to transport or replace. Two of them, viz. the polar crane and the reactor pressure vessel (RPV) are safety grade equipment. The polar crane, a 600 ton machine, sitting below the dome and above the RPV, can be seen as the limb of the reactor. In a PWR, RPV is where all the action begin. It contains the fuel assembly immersed in water. Heat generated by the fission of uranium atoms is transferred to water, which is used to produce steam that runs the turbine. RPV is known as the heart of the reactor and it determines the life of the plant. The third equipment is the generator transformer used for upgrading 24 kV electricity to 400 kV. This is not a safety class equipment, but if it trips the reactor will have to be shut down. These defective equipment which should have been returned to the manufacturers have been accepted and installed in the plant. This study is based on information available in published papers, annual reports, news releases and responses to the right to information requests. The complete data on equipment is available in documents such as the Detailed Project Report (DPR), the Preliminary and Final Safety Analysis Reports (PSAR and FSAR) and the inspection reports. NPCIL hold these documents which are the property of ASE in a fiduciary capacity.

2 The Defective Polar Crane

The polar crane is a safety grade equipment, installed in the reactor building (RB) and its first use is for the erection of nuclear steam supply system (NSSS) equipment such as RPV, pressurizer and steam generators (SG). The polar crane which moves on a circular rail above the reactor shaft can perform transportation and hoisting operations anywhere in the RB. The crane will be used for planned repairs and transportation of nuclear hazardous loads such as spent fuel [1].

2.1 Manufacturing history

Media reports from Russia show that NPCIL experts in charge of the crane had done their job of quality assurance (QA) with text book like precision. On March 19, 2003, they visited the Ural Heavy Machine Engineering Works (OMZ) for auditing the manufacturing capabilities and signed the protocol [2]. On 17 August 2004, OMZ conducted acceptance-transfer tests of the first polar crane which according to website, www.nuclear.ru/eng/press/other_ news/1800949, that it complies with stringent technical requirements.

2.2 NPCIL sees defects in the first crane

OMZ shipped the first PC to Koodankulam on 17 December 2004 [3]. The annual report of NPCIL for 2004-05 records that all major equipment for Unit-1 such as Reactor Pressure Vessel, Upper Unit, Pressurizer, Reactor Coolant Pump Casings, Polar Crane have been delivered to Site [4]. On 25 October 2005, nine months after its arrival, KKNPP Project Director said that erection of the polar crane and other equipment were under way and RPV would be erected early next year [5] The erection of polar crane was not under way in October 2005. The AERB annual report for 2007-08 says that its Advisory Committee for Project Safety Review (ACPSR) held 4 meetings and reviewed problems observed in polar crane erection and implementation of corrective measures [6]. AERB did not take any decision, instead it just acted on a decision made elsewhere. "As per the joint protocol between Site and Russians, a decision was taken to temporarily limit the maximum load capacity of the polar crane up to 332 Te due to tilting of the main hoist fork under a load of 350 Te. The polar crane was then released for the erection of SG, RPV and pressurizer, etc. for unit-1. Suitable modifications were incorporated to eliminate the problem subsequently" [7]. The erected crane has a maximum load capacity of 332 tons as against the nameplate capacity of 450 tons. The AERB report does not specify as to how the problem was eliminated. According to the KKNPP time line, the polar crane was installed in April 2007. It appears that the crane was installed without AERB's full consent as they only released the crane for erection of other equipment. The crane has other important functions too.

2.3 The second one is good- says manufacturer

AERB says that the crane for unit 2 also has problems- "some base metal defects and weld defects were observed at site for polar crane for unit-2, which were not observed in the manufacturing plant. These defects were rectified at site" [8]. The second polar crane reached the site in July 2005 and it was installed in the second reactor in December 2007, 30 months after its arrival. AERB has not stated anything about its hoisting capacity. If it were unproblematic, NPCIL would have installed it in the first reactor as they had a formidable 'first of its kind' task of equipment erection in a 1000 MW reactor. However, according to the manufacturer's website, "tests of the second polar crane have been successfully carried out at Kudankulam. The crane is characterized by an exceptionally high safety factor and excellent working capacity in extreme conditions. It can survive a Richter magnitude 9 earthquake" [9].

Between 2005 and 2011, OMZ manufactured 125 small and large cranes. Of these, 57 were supplied to Kudankulam. Two polar cranes supplied to NPCIL are missing from the list published by the company. OMZ did not manufacture this safety equipment for any other atomic power project, even in Russia [10]. The polar crane for Leningrad NPP-2 under construction now is being manufactured by OJSC ZARUBEZHENERGOMONTAZH [11]. It seems OMZ is a dedicated facility for making safety grade cranes for Indian nuclear power plants alone!

2.4 The Safety significance of the polar crane

The Finnish nuclear regulator, STUK says that: there are tens of cranes in use at the nuclear power plant, but only the cranes used in the transfer of nuclear fuel or in other safety significant lifting operations are under special control of STUK. The polar crane is one of these, and it is assigned to safety class 3 [12]. A US NRC Survey of Crane Operating Experience at U.S. nuclear power plants during 1968-2002 shows an increase in load drop events involving overhead cranes [13], which can be considered as an ageing effect. KKNPP-1 polar crane has shown an ageing effect even before its installation. The consequences of load-drop events can be catastrophic according to a US NRC 2005 guideline: "The principal safety concerns related to heavy load handling at these plants involve load drops that damage either the spent fuel storage facilities, the fuel in RPV, or the residual heat removal capability while the plant is shut down with fuel in the reactor vessel. If a floor breach were to occur during a load drop, safety-related components located on the lower floors could be adversely affected. A load drop that penetrates the operating floor in certain areas could simultaneously initiate an accident and disable equipment necessary to mitigate the accident" [14].

3 The Reactor Pressure Vessel (RPV) with beltline welds

3.1 The Importance of RPV

RPV is a long lead item (LLI) that takes about 3 to 4 years for manufacture. Since it cannot be replaced, its health determines the reactor's lifetime. The bottom portion of the RPV, known as the beltline is more vulnerable for premature ageing (a process known as embrittlement) due to the impact of neutrons flying away from fuel assembly during the chain reaction. According to an IAEA report (2009), the concentration of neutron sensitive elements such as copper, nickel, phosphorus, vanadium, manganese and silicon (used either as an alloyant or present as an impurity) in base metal and weld metal (b) and welds in the beltline region cause early embrittlement[15]. The beltline region of RPVs fabricated during the 1980's were made of three forged rings and had two circumferential welds. The modern trend is to use one large ring without any weld. There is also strict regulation regarding the concentration of neutron-sensitive elements such as nickel in base and weld metals [16]. VVER RPVs fabricated before 1990 had high nickel-manganese content in the base metal and weld metal. According to the European Commission Project on Nuclear Safety in Central and Eastern Europe "the RPV integrity of WWER-1000 plants has been recognized of high safety concern due to relatively high nickel concentration in the vessel beltline area welds, which may lead to a higher than anticipated embrittlement rate" [17]. An embrittled vessel may, under emergencies like a loss of coolant accident (LOCA), break up and form missiles which can destroy the containment buildings, leading to the release of radioactivity [18, 19]. 25 pressurized water reactors with an average age of 19 years in 10 countries have been retired due to premature ageing [20]. Two reactors in Belgium have been shut down since mid-2012 because of cracks on the RPV [21, 22]. The Sharon Harris NP in US has been shut down since 17 May 2013 for the same reason [23].

3.2 The promise of an RPV without welds in the beltline

The safety community within India's nuclear establishment was acutely aware of the embrittlement risk of VVER RPVs. The beltline welds of RPV was mentioned for the first time in a brochure published by NPCIL in 1998. SK Agarwal, the Station Director of KKNPP mentions this in a paper published in an international journal: "the pressure vessel has no weld joints in the core region" and the "design features extensively negotiated" includes "verification of the designs by Indian engineers who will also over-see the quality of equipment, witness necessary inspection and testing during manufacture" [24]. According to the above paper, the Core damage frequency (CDF) of the proposed reacor in one in 10 million reactor years. (CDF "is a term used in probabilistic risk assessment (PRA) that indicates the likelihood of an accident that would cause damage to a nuclear reactor core. These are considered serious because damage to the core may prevent control of the nuclear reaction, which can lead to a nuclear meltdown" [25]. RPV for KKNPP-1 reached the site in January 2005. AERB gave its consent to erect RPV in August 2006, 20 months after its arrival and the erection was done only after April 2007, after lying idle for more than 27 months. This is the first RPV in the world which had to wait this long before being taken inside the reactor building!

3.3 The received RPV has beltline welds

The AERB revealed in 2008 (three years after the receipt and one year after its installation) that the original design of RPV did not contemplate welds in the core region. However, the vessel now used has two welds in the core region“ [26]. The estimated CDF of the reactor, according to S. Bajaj, the then Senior Executive Director (Safety), of NPCIL is 1 in 100,000 reactor years [27], hundred times higher than the promised one. Three important questions are: (a) why the NPCIL accepted a vessel, which is different from the one that was promised, (b) why did the AERB give its consent to erect it and (c) why this information was concealed for three years. Thy have been claiming that the NPCIL team camping at St Petersburg was performing their quality assurance (QA) function right from the beginning of the fabrication and that the AERB has been overseeing this [28]. If this were true, they knew about it in 2002, the year fabrication of the RPV started. The belt-line weld is an important safety issue, but it seems that the received vessels also had other problems. While delaying consent for 20 months, the AERB did not mention that this was primarily due to the welds. In order to comprehend this, we will have to consider the situation in Russia in general as well as the conditions of the factory where the vessel was fabricated.

3.4 The Fabricators of RPV in Russia Too fast to believe

Izhora Zavody and Atommash were the two major equipment manufacturers for VVER-1000 reactors in the erstwhile Soviet Union. After the fall of Soviet Union in 1991, Atommash was bankrupted and privatised in 1995. Izhora was on the verge of bankruptcy in 1998 when it was acquired by a private company OMZ Group. Between 1999 and 2002, Izhora received orders from ASE for five traditional PWR-1000 reactors to Iran, China and India [29]. ASE placed the order for the manufacture of KKNPP reactor equipment to Izhora in June 2002 [30] and the RPV was ready by July 2004, within 25 months of receipt of order. Between April 2002 and May 2005 (a period of 38 months) Izhora delivered four RPVs to China and India, one RPV in less than 10 months. Details of RPVs delivered by Izhora during 2001-05 are given in table 1: According to S K Jain, the minimum manufacturing lead time for RPV is 36 months [31], possible only under ideal conditions such as the availability of raw materials and a qualified workforce. RPV fabrication requires special steel and weld materials, which were not available in Russia, as the nuclear construction had collapsed post-Chernobyl. Izhora has set up its steel smelting unit only in 2009. While the vessel for KKNPP was 'fabricated' in 25 months, Izhora took four years

Reactor	Contract signed in	Finishing date	Duration from the contract in months	Time from the last completion in months	Reference
Bushehr	1998	16.11- 2001	36+	nk	35
Tianvan 1	11-1999	03.04 -2002	27	4	36
Tianvan 2	-do-	29.11- 2002	41	5	37
KKNPP 1	06-2002	07-2004	25	15	38
KKNPP 2	-do-	03- 2005	34	9	39

Table 1: RPVs Delivered by Izhora OMZ- 2001-2005

from 2008 to fabricate a new and genuine AES 92 RPV for Bulgaria [32, 33]. The fabrication of RPV for Finland's Olkiluoto reactor done in Japan took 60 months [34].

Was it possible for Izhora to fabricate new RPVs so fast in only 25 months? As of December 31, 2002, Izhora's consolidated balance sheet reflected an accumulated deficit of $108 million as a result of net losses incurred prior to 2000 including substantial impairment charges to property, plant and equipment in 1999 [40]. Out of $292 million Indian supply order, to be delivered before December 2006, the company had received $72 M in 2002. In 2000, Izhora had 16,624 workers, a figure that had shrunk to 9,350 in June 2003 [41]. OMZ was experiencing an acute shortage of qualified workforce as this study shows: "The Izhora lost most of its government contracts in the 1990's and slashed its workforce, had to bring in qualified workers from all over Russia. The RPV it shipped to Bushehr in November, 2001 was its first in 14 years" [42]. The RPV for KKNPP-2 was ready within six months of despatch of the first one. This would have been possible if only Izhora had two well-oiled production lines. We will now explore from where these RPVs could have come.

3.5 The leftover of a failed military industrial complex

The Three Mile Island accident of 1979 had sealed the fate of civilian nuclear technology in the West and its allies, as only two non-nuclear countries opted for civilian nuclear power thereafter. The Eastern bloc under the leadership of the Soviet Union had to wait for six further years for a nuclear collapse. During 1986, 29 VVER-1000 units were under construction in Eastern Europe. Work on 22 of these units was cancelled after the Chernobyl accident of April 1986, leading to the near collapse of the VVER program [43]. Equipment for these units were either already manufactured or under assembly. For instance, as of 1986, "Atommash had made 14 VVER-1000 RPVs, five of which remained at the facility" [44] During the 1990's, Europe including Russia, tightened their standards for PWR RPVs. (Since 1990, Russian General Regulations for Nuclear Power Plant Safety requires a CDF of one in 10 million reactor years, [45] the pre-1990 RPVs with beltline welds have a CDF of one in 100,000 years.) Under the new regulations, Soviet era RPVs made of high nickel-manganese steel and with beltline

Ser	Parameter	V 320	V 412 AES 92	Ref Slide
1	Length of RPV (mm)	10885	11185	21
2	Number of CPS control rod	61	85-121	21
3	Coolant flow rate m3/hr	84800	85000	20
4	Steam generation capacity m3/hr	21200	21500	22
5	Type of pump	RCP-195	RCP-1391	22
6	Steam generator	PGV-1000	PGV-1000	21

Table 2: Dimensions of RPV- V 320 And V 412 [47], Slide numbers from the presentation are given in the last column. Note: The names of the pumps and steam generators in row 5 and 6 given in Russian were translated using free language translator at http://languagetranslator.codeplex.com/ releases/view/101379

welds are not acceptable in Europe.

3.6 Size differences between the old and the new versions of RPV

The majority of the VVER 1000 RPVs fabricated before 1990 were of V320 design. The KKNPP contract was for a V412 model, which belongs to the 3rd generation of reactor designs. Beltline welds are not the only distinguishing features between V320 and V412 models. Ryzhov S.B et al have in a presentation shown the differences between V320 and V412 RPVs. (see table 2). These are (a) V 412 version is 300 millimetre taller than V 320, (b) the head of V 412 has 121 perforations for control rods in contrast to 61 in V320 and (c) there are also differences in coolant flow rate, steam generation capacity and the types of pumps used in the two models. Since the only difference between the heads of RPV V320 and V412 is the number of penetrations for control rods, the extra holes could be drilled or a new head could be fabricated. For the rest of the vessel, Izhora could have used the forgings of traditional (V320) RPVs and that is why there are two welds in the received vessel. If this is the case, the supplied RPV would be shorter by 300 mm. These differences in length, size, shape and position of the pipes is likely to have caused endless modifications to the plant buildings and fixtures. NPCIL has mentioned amendments to the project as one of the reasons for the delay of the project [46].

After receiving the first RPV in January 2005, the NPCIL requested OMZ to expedite the delivery of the second RPV. OMZ says that at the request of the customer delivery of equipment (RPV for KKNPP-2) reduced by almost half a year" [48] and this was shipped in June 2005. When they could not erect the first one, which was still lying on the beach in Kudankulam, what was the urgency in expediting the second one? After the receipt of the first RPV, NPCIL might have lost its trust on the partner in St Petersburg, who had scant respect for drawings and sketches in the contract. To proceed with the construction of KKNPP-2, the engineers wanted to see the vessel, before continuing the piping and other works, so as to reduce the number of 'modifications' to unit 2. Effectively, they had to design the feet as per Russian shoes. Clearance for Equipment Erection was granted for unit-2 in June 2007"

[49]. It is not known whether "the proposal for re-engineering of the base raft" [50] mentioned by the AERB has anything to with the equipment problem.

3.7 More RPV related problems

AERB is releasing information about the reactor in instalments. Its annual report for the year 2008-09 has one new aspect in one sentence which reads as: "implications of eccentricity between RPV- 2 centerline and its cavity axis to be examined and reported" [51]. Again in the Annual Report for 2009-10, there is a more detailed narration. "The core barrel axis shift with respect to axis of RPV was found to be more than the specified value. The Passport of RPV has been corrected by manufacturer to reflect these modifications. Site was asked to prepare a document reflecting the clarifications provided by the designers on the effect of shift and remarking of the axis on RPV, etc. for future reference" [52]. AERB should have noted all these things during the final inspection before giving its consent for erection. Th reason for releasing these information, more than two years after the erection is mysterious.

4 The Damaged Generator Transformers

In 2007, two single phase generator transformers 24- 400 kV of capacity 417 MVA manufactured in Ukraine were received from Russia in a damaged condition. Larsen and Toubro (L&T) the construction sub contractor at the site says: "Having approached many Indian transformer manufacturing companies for rectification of the damage, officials at KKNPP could find nobody to take up the challenge. The main reason was that it was not possible to make a factory set-up and testing facility at the site while it was even more difficult to transport the transformer to any manufacturing unit". "L&T took it up as a challenge, had dismantled the entire parts of the transformer, rectified, re-assembled and Tested it without compromising the Russian manufacturers quality and safety standards" [53]. The generator transformer is for voltage upgradation from 24 kV to 400 kV and it does not have any safety function. But if it trips, the reactor will have to be shut down, as happened on 15 April 2013 at the Madras Atomic Power Plant [54].

It is not unusual to have generators or transformers getting damaged in long distance transportation. In 2007, a generator transformer was damaged while in transit to Fort Coulham NPP in US [55] Out of a consignment of 7 such transformers from Austria to South Africa, one was damaged in 2009[56]. On the probability of both the transformers in one consignment to KKNPP being damaged, System Analyst Shankar Sharma says: "One cannot say it is normal; but also not unheard of. Transformers are very sensitive pieces of equipment, and need extreme precautions. But transportation over long distances is always a problem; especially if it is multi-modal (over road, rail and ocean)" [57]. The cost of one transformer is about US 6 million and it has a manufacturing lead time of more than one year. The receipt of such an important equipment in a damaged condition is not mentioned in the annual report of NPCIL, where as in instances quoted above, investigations were carried out and their reports were published.

The crane, RPVs and two generator transformers had defects and the normal recourse was not to accept the damaged or substandard equipment or return the cargo to the manufacturers. Instead, NPCIL accepted them and AERB concurred. Before the installation of polar crane, there was a VIP visitor at KKNPP. That visit presumably solved the problems with the equipment, once for all.

5 The Mock-up inspection of an un-installed RPV

According to a report published in the Hindu on 23 January 2007, Sergie Kirienko, the chief of the State Atomic Energy Corporation, Rosatom, inspected "the Reactor Pressure Vessel installed in the first reactor" accompanied by DAE Secretary, Anil Kakodkar, NPCIL's Chairman and Managing Director S.K. Jain, Director (Projects) S.K. Agrawal and Project Director (KKNPP) K.C. Purohit [58]. This was two days before the Delhi visit of the Russian President in which several deals were decided. The inspection of equipment is done by specialists; Kirienko is a bureaucrat turned politician.

The NPCIL annual report for 2007-08 says that "the year marked the erection completion of all the heavy lift equipment including RPV, Pressurizer, steam generators, reactor coolant pump, emergency air lock and main air lock in Unit-1" [59]. The installation of polar crane of KKNPP-1 was done in April 2007, two months after the 'inspection' by Kirienko[60]. The KKNPP time-line does not show the exact date of erection of RPV, but it does state that the erection of Nuclear Steam Supply System (NSSS) Equipment (which includes RPV) was completed in July 2008. Since the polar crane was not installed on 22 January 2007, RPV was also not installed in the reactor on that date. So the inspection of the installed RPV of the first reactor by Sergey V. Kirienko on 22 January 2007 was indeed a mock-up. There are a couple of questions about this high level event attended by the top brass of DAE and NPCIL. These are (a) why Kirienko's Kudankulam visit was tagged as a non-event? To speed up the forthcoming deals? Or was it just an alibi to be away from Delhi? (b) why did Kirienko rush to Kudankulam in the midst of a tight schedule connected with the state visit of the Russian President? Had it been for the negotiations of further projects, Delhi would have been the proper place, since the officials accompanying the President were there and the deals are fixed there. (c) did the joint protocol between Site and Russians mentioned in the AERB annual report which clinched the issue of the polar crane, happen during the 22 January 2007 meeting? Kirienko is also the chairman of the board of directors of the Atomenergoprom, a 100% state-owned holding company that unites Russian civil nuclear industry and was appointed to head Rosatom, on November 30, 2005 [61]. Three months after his appointment as Rosatom chief, he was "taken to the (KKNPP) site by AEC Chairman to review the progress of the construction of two reactors". So this was his second visit in eight months. There is another interesting story related to him. Alexander Stepanov the CEO of Atomash (the company which had several reactor equipment manufactured two decades ago lying in its warehouses) who is now facing criminal proceedings for charges of corruption had said that, "he (Stepanov) was expected to 'donate' several assets to Sergey Kiriyenko - the Head of State Corporation 'Rosatom' personally" [62]. According to reports, India and Russia have already agreed for the commerce of six reactors four at Kudankulam and two at Haripur- during the XII Five Year Plan (2012-17) [63].

6 Main Observations

The Kudankulam project is the first case of import of nuclear plant by India during the past four decades. The Government of India is planning to import twenty reactors, about half of them from Russia, worth more than US$100 billion during the next two decades. This study shows that the nuclear establishment in India does not have the capacity for quality assurance, a strict and enforceable regulatory regime, an independent regulator and accountability and peer review which are essential for such large deals with global catastrophic potentials.

6.1 Total Collapse of Quality Assurance

Inspection and Acceptance test six years after shipping of RPV. The Russian designer Gidropess has the details of an ultra sonogram test done by eight specialists from the Croatian company HRID: "In March 2011 on atomic power station Kudankulam the system of ultrasonic inspection of metal of the reactor pressure vessel has passed acceptance tests. On all parameters the system has shown conformity to technical project requirements. In connection with positive results of acceptance tests the system is accepted by the customer (Joint-Stock Company msrjexport and NPP Kudankulam) and recommended for application for NPP Kudankulam in pre operational and operational inspection" [64].

The inspection, and acceptance of RPV by ASE and NPCIL was carried out at NPCIL's site, six years after its shipment from Russia and four years after its installation in the reactor. If the test was part of the contract, that should have been done before the acceptance of RPV by NPCIL in St Petersburg in Nov 2004. Few questions: 1. Why was this acceptance test delayed by six years?
2. Why was it not done at the shop floor itself?
3. What would they have done if the machine failed in the test? Incidentally, if the reactor was commissioned a scheduled in December, 2007, this 'mandatory' inspection would not have been possible because the vessel would have been highly radioactive.

The Croatian experts visited Kudankulam again in May 2012. The Hindu reported on 22 May 2012: "The upper portion of the Reactor Pressure Vessel (RPV) of the first reactor was opened. A Multiple Stud Tensioner was used to loosen the 54 bolts on the RPV, while keeping the electrical circuits intact, to expose the 163 dummy fuel assemblies in its core for removal before this week-end. Robotic inspection will also be conducted alongwith manual examination to check all welding joints since it is a mandatory exercise to be conducted after the hot run. Experts from Croatia and Germany will coordinate the exercise" [65]. After dummy fuel was removed from the reactor, "they and NPCIL scientists inspected the reactor pressure vessel and other systems" [66] "as part of the mandatory IAEA inspection" [67].

Not all acceptance were done years after shipment and installation. Assembly and acceptance of the second trestle crane manufactured at Uralmash Machine-Building Corporation for KKNPP started in July 2007, trial assembly was carried out in October 2007 and shipment was done on 06 Feb 2008[68]. Again, acceptance tests for RPV for Novovoronezh NPP-2 in Russia manufactured by Izhora was successfully completed on November 30, 2010 at the shop floor, 16 months ahead of its shipping in March 2012[69].

When the safety concerns of obsolete RPV at KKNPP was first raised on 16 June 2012[70] NPCIL said that "the inspections (of RPV manufacture) right from the selection of material, from the billet stage to forging, fabrication, and post fabrication have been carried out by experts from NPCIL and Russian Regulators and a specialist group of AERB has reviewed the inspection details" [71]. If the three-tired system were working efficiently, the KKNNP reactors would not have been saddled with prematurely aged and defective equipment. The roles of NPCIL and AERB are clear from the case studies presented in this report. As regards the Russian quality control, Rostekhnadzor (RTN) the nuclear regulator of Russia made the following comments about Izhora in 2009. "The main causes of violations in the NPP construction works are insufficient qualifications, and the personnels meagre knowledge of federal norms and rules, design documentation, and of the technological processes of equipment manufacturing. In particular, the top management have been advised of the low quality of the enterprises products and have been warned that sanctions might be enforced, up to suspending the enterprises equipment production licence" [72]. A 2011 report by the Nuclear Energy Agency of OECD on the issue of substandard and counterfeit items getting into the global nuclear supply chain says that: "no written policies and procedures for preventing, detecting, reporting and prosecuting confirmed counterfeit and fraudulent activity has been developed by the Russian Regulatory Body" [73].

Counterfeit items is not an uncommon problem in nuclear commerce. The World Nuclear News reports that "safety-related control cabling with forged documentation was found to have been installed at the four reactors in South Korea. In the event of an accident, the cables send signals from the reactor operating systems, such as cooling, to the control room" [74]. From S Korea, there are also reports of "non-safety-critical parts supplied to a number of nuclear power plants using forged quality control certificates. Two reactors have been shut down while such parts are replaced. The Ministry of Knowledge Economy announced on 5 November 2012 that state-owned utility Korea Hydro and Nuclear Power (KHNP), which owns and operates all 23 of Korea's nuclear power reactors,had allegedly been supplied with falsely-certified parts for at least five of them. The company told the ministry that eight unnamed suppliers forged some 60 quality control certificatescovering 7682 components delivered between 2003 and 2012" [75].

6.2 Systemic Failure, not personal corruption

Recently, the CEOs of three companies - Ziopodolk[76], Informtekh[77] and Atommash[78] all manufacturers of nuclear equipment, have been jailed for corruption. Two of these companies had supplied equipment to Kudankulam Nuclear Power Plant[79]. The issue before us now is not one of individual corruption. The civilian nuclear establishment of Russia has decided, at the highest level, to dumb the surplus inventories of obsolete equipment to Asian-African countries, where regulations are lax or non-existent. In India, there is a systemic failure, because of lack of accountability and transparency. In an interview with a Finnish journalist, Kakha Bendukidze[80], the CMD of OMZ until 2004 opined that "in these countries (China, India, and Iran) the selection is made as a compromise of politics, price, and quality". He added that the Finnish contract "is the first time that the process is completely transparent; the power plant is being built by a private company with private funding" [81].

7 Conclusion

The problem of Kudankulam is not of a few replaceable valves, supplied by an unscrupulous subcontractor. It is also not about the corrupt deals of individuals. There is an organized and well-coordinated plan to dispose of the surplus inventories of 1980's which are unacceptable in Europe as they are obsolete and unsafe. Equipment such as RPVs, polar cranes and generator transformers are bulk items, which are either irreplaceable or extremely difficult to replace. The first two are also safety grade equipment, any malfunction in them has the potential for a catastrophic accident. Even before the two reactors have been commissioned, the authorities in India and Russia are rushing to bring in more reactors. Obsolete and counterfeit equipment for about a dozen reactors are lying in the warehouses of the manufacturing units in Russia either in finished form or at intermediate stages and countries such as Bangladesh and Vietnam, with low expertise in reactor physics, are the targets. The business as usual attitude of the Government of India and her regulators will be detrimental to the eco-system and well-being of Asia and her three billion people. Despite the absence of whistle blowers protection, scientists within the establishment have provided, albeit inadvertently, sufficient evidence about the lack of quality assurance and transparency in the Russia-India nuclear deal. Recently eminent scientists form premier national institutes in India have appealed to the government, to freeze all activities at the site till an impartial safety audit is complted. We have experienced a couple of serious nuclear events at Windscale, Chelyabinsk, the Three Mile Island, Chernobyl and at Fukushima. All these can be attributed to machine failure, human error or, acts of God. If one of those counterfeit equipment at Kudankulam fails, it will be the first man-made radiological disaster from civilian nuclear technology. The result will be an unprecedented disaster of a global scale, in which millions of people with no option for evacuation will be subjected to slow radiation poisoning. The number of survivors subjected to slow death will be several times larger than those in Hiroshima-Nagasaki, the first large-scale, man-made radiological disaster. Paying attention to the disaster potentials of the defects highlighted in this account can prevent the largest ever gradual slaughter of life and the destruction of ecosystem. All commissioning activities at and work on future projects should be frozen till the issues are investigated by an independent body of experts appointed by the National Science Academies of India, Ruissia and other countries with advanced nculear research program under the aegies of the United Nations.

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