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Experimental Study of Safety Membrane Device in a Nuclear Reactor

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***Abstract*— In this paper work Safety membrane device is to analysed used in Nuclear Reactors of Submarines. In Order to release the pressure to the environment, when there was any leakage in the steam carrying tubes of Nuclear reactor, the safety membrane devices are used. Safety membrane device is used on the fitment of Removable shielding blocks structure which is used at the secondary unit of the Nuclear reactor. Safety membrane device is essentially a rupture disc assembly and the requirements of it is to be leak tight during normal operating conditions, as well as burst at a predetermined pressure of 100Kpa, thereby releasing the excess pressure to the environment. Safety membrane device will be fitted in between top cover and membrane unit assemblies.**

***Keywords*— Safety Membrane Device, Central Shield Structure lower block. Central Shield Structure upper block. Pressurized Water Reactor, Human Machine Interface**.

I.INTRODUCTION

Safety membrane device is essentially a rupture disc assembly and the requirements of it is to be leak tight during normal operating conditions, as well as burst at a predetermined pressure of 100Kpa, thereby releasing the excess pressure to the environment. Safety membrane device will be fitted in between top cover and membrane unit assemblies. The top cover is to prevent the damage done by lead membrane to the nearby objects because, at the time of bursting, the lead membrane bursts with high speed which will cause damage to the nearby objects as well as the surrounding equipment. Also, it helps in deflecting the jet of steam leaked from the steam tubes after the bursting of the membrane. Also, the tie rod attached with the membrane unit prevents the falling of lead fragments. Nuclear safety covers the actions taken to prevent nuclear and radiation accidents or to limit their consequences. The nuclear power industry has improved the safety and performance of reactors, and has proposed new safer (but generally untested) reactor designs but there is no guarantee that the reactors will be designed, built and operated correctly. Mistakes do occur and the designers of reactors at Fukushima in Japan did not anticipate that a tsunami generated by an earthquake would disable the backup systems that were supposed to stabilize the reactor after the earthquake. We have fabricated a safety membrane device to use in nuclear reactors of submarine. In Order to release the pressure to the environment, when there was any leakage in the steam carrying tubes of Nuclear reactor, the safety membrane devices are used. Safety membrane device is used on the fitment of Removable shielding blocks structure which is used at the secondary unit of the Nuclear reactor.

II.LITERATURE REVIEW

1. **YAMAJI and Kiyoshi SAKO-** The paper states that for shielding design, it is necessary to evaluate the exposure dose equivalent of the crew and others due to direct gamma-ray sky shine gamma rays during a hypothetical accident with fission products being released into the containment vessel. The computational conditions are as follows the accident is assumed to occur immediately after continuous reactor operation at full power to the maximum degree of burn-up.
2. Grant Elliott-In light of the devastating political and social effects of an accidental (or intentional, but unsanctioned) nuclear detonation, an intricate network of safety and control mechanisms has been implemented in the US nuclear arsenal. We discuss these measures, including technological solutions to restricting the use of weapons and preventing accidents, as well as procedural solutions which attempt to mitigate the risk of mistakes or intentional misuse. Technologies covered include Environment Detection Sensors (EDS), Permissive Action Links (PAL), Enhanced Nuclear Detonation Safety (ENDS), Insensitive High Explosive (IHE), and Fire Resistant Pits (FRP).
3. Samir Yousha El-Kameesy1, Sahar Abd El- Yaser Abd Allah -In the present work, the lead has been observed to be promising gamma-ray shielding material capable to minimize the nuclear radiation hazards below the permissible dose. The dependence of the radiation shielding properties of the related glass on the percentage concentrations of PbO, B2O3 and ZnO combinations has been experimentally undertaken.
4. Pichet Limsuwan And Weerapong Chewpraditkul- 'Development of Bao: B2O3: Flash glass system for gamma-rays shielding materials'. The shielding properties of two different lead-free materials-tin and a compound of 80% tin and 20% bismuth-for protective shielding materials.

III.SELECTION OF MATERIALS:-

Some important property of lead as follow- It's very soft, has low melting point (327^{0}c) with high density (11.34 g/cm^{3}). It has low electric conductivity; high coefficient of thermal expansion, high corrosion resistance and good lubricating property and it is used as shielding against X-rays and gamma rays.

Material	Thickness (cm)	Density(g/cm^3)
Lead	0.4-1	11.34
Concrete	2.4-6.1	3.33
Steel	0.99-2.5	7.86
Wood	11-29	0.56

Fig.1 Properties of different materials.

There are different shield material used such as concrete with ceratine, steel and lead but we select lead due to above mention properties and its suitability in safety device The lead devices means lead plate is located in between central shield structure lower block (CSS-B1) & central shield structure upper block (CSS-B2) .When temperature & pressure of the steam generator exceeds limit, membrane bursts and excess steam transmit to vacuum collector tank. to maintain the temperature of steam generator if the excess temperature generated in the steam generator so this tube of steam generator compresses so more pressure and temperature produce inside the tube it will burst and whole plant accident take place so avoiding all this thing we used this lead safety plate to maintain temperature and pressure inside the tube .The material selected for safety membrane device is Lead of purity 99.99% and the material to hold the Lead membrane unit is Aluminium. Lead is mainly selected due to its softness, high density, good sensitivity for pressure and temperature and also, unlike other metals its thickness can be fabricated to thickness suitable for bursting at the predetermined pressure. Aluminium is also selected for its softness and thermal conductivity. to hold the safety membrane device i.e. the Lead membrane, metal like Aluminium is well suited.

IV.EXPERIMENTAL ANALYSIS-

A. Fabrication Of Lead Membrane-

Lead sheet of dimension 140x140mm is cut from the lead sheet of thickness 1.6mm.Cut the Lead membrane by using cutting fixture of cutting edge diameter 129mm, cutting fixture includes cutting punch and screw jack setup, After above operation the lead disc will be having the diameter of 129mm and thickness of 1.6mm.After this the rolling is done on the lead membranes by rollers (uniformly distributed) is rolled over the lead disc to reduce thickness between 1.30-1.35mm.After rolling, the diameter of lead disc is again increased due to material flow. Sizing and grooving fixture of diameter 117.8mm and grooving diameter of 99.6mm is used to obtain the final dimension on the lead disc. The final required dimension of lead membrane is diameter 117.8mm and thickness 1.30- 1.35mm is obtained. Grooving depth is 0.55mm from the surface of the lead disc. Checked dimensions at multiple places of the surface, minimum 8 places, using Micrometre. After checking all the dimensions, the lead disc is connected with aluminium flanges and it is tightened with torque wrench for set torque 5Nm.

B. Burst Test-

1. for Burst test at Room Temperature-The control panel controls the flow of nitrogen from the supply to the Heating chamber through the solenoid valve. The control panel sends the signal to the solenoid valve which allows the flow of nitrogen of lesser than or equal to 3 Kpa per second to the heating chamber, when the temperature of the chamber reaches the set temperature in the control panel. The control panel supplies the nitrogen continuously to the heating chamber till the lead membrane discs bursts. When the lead membrane discs bursts, the control panel signals the solenoid valve to stop the flow of pressure to heating chamber. The pressure at which the lead disc bursts will be shown in human machine interface (i.e.) the display unit. If the pressure exceeds the abort pressure, the test will be aborted automatically releasing the pressure to the environment via pressure regulator connected to the output of the solenoid valve.

2. For burst test at 120^{0}c-The predetermined temperature is set in initial temperature at which the pressure will be allowed to enter inside the heating chamber. Then the pressure at which the test has to be aborted has to be entered. After entering all the required values the Cycle start button is pressed to start the test and the heater is also turned ON manually. In here the heater is turned ON manually because the same steps were followed for Burst test at room temperature which does not involve the supply of heat. When the heat inside the chamber, which is measured by means of thermocouple, reaches the set temperature, the proportional integral derivatives send the signal to solenoid valve and the pressure enters inside the heating chamber via the pressure regulator. The pressure at which the lead disc bursts will be displayed on the human machine interface.

C. Experimental Procedure

1. Refer to the Burst Test Screen.

2. The user has to enter the following settings:

Abort Pressure- At this pressure, the test will be aborted. This is to ensure safety & operation of the test setup within desired pressure.

Incremental Pressure-This is the value by which the pressure will be applied to the membrane. For eg: A value of ‘2’ will result in pressure being applied in steps of 2, i.e 2,4,6,8..& so on.

Soak Time-This is the time in minutes for which the test setup will wait after achieving the desired temperature & before starting the application of pressure.

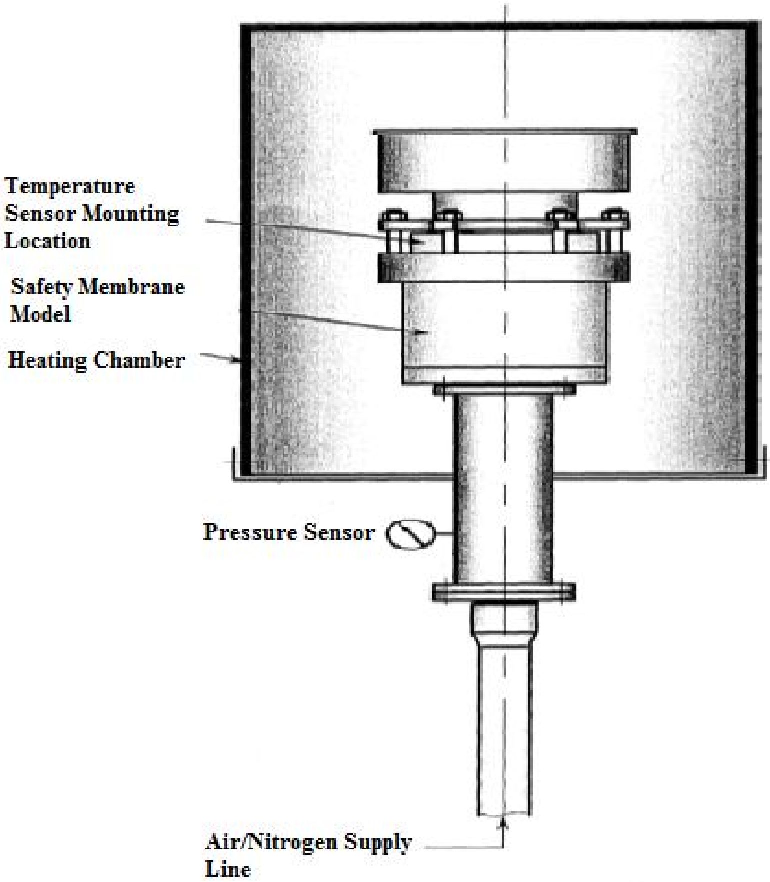

Fig. 2 Schematic of Test Set Up for Safety *Membrane Device.*

Initial Temperature-This is the value of the ambient temperature to be achieved beforethe pressure is applied.

3. After entering the above settings, the user has to press the cycle start on the control panel to start the test.
4. The Burst Test Screen will show the present temperature & pressure values along with the trend for Pressure v/s time
5. If the membrane bursts before the abort pressure, the test will be successful & will indicate the result & the burst pressure.
6. If the membrane does not burst before the abort pressure, the test will be aborted & will indicate the abort pressure.
7. The test values are stored in the memory card in the programm logical control.

The screen shown is viewing screen for the burst test. It shows the following parameters screen depicts the test result for Burst Test in case of successful completion of the test. It also shows the pressure at which the test is completed.

1. Abort Pressure 2 Incremental Pressures 3 Initial Temperatures4 Soak Time 5 Test Statuses 6 Present Temperatures 7 Present Pressures

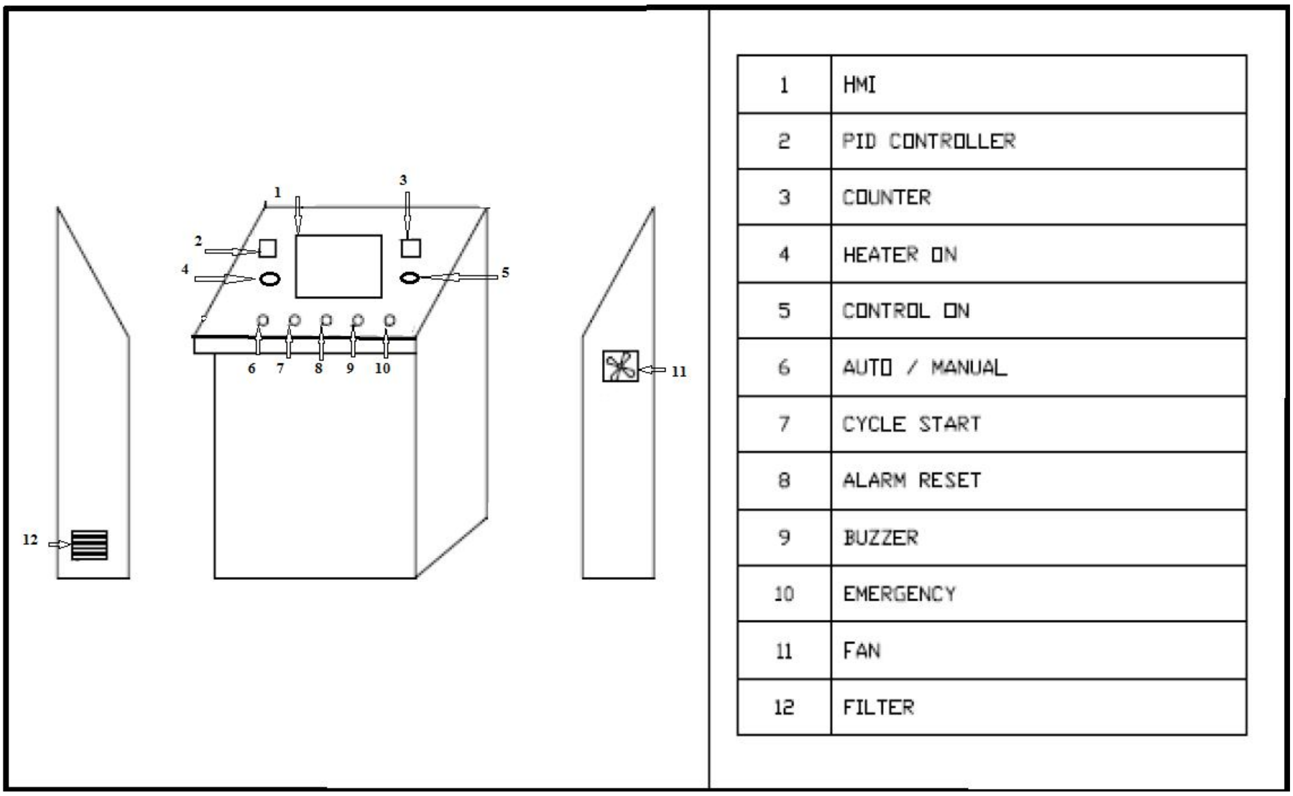

Fig.3 Block Diagram of control panel.

V. RESULT AND DISCUSSION

A. For 120 ^{0}C:-

Sr.No	Membrane Thickness In Mm	Groove Depth In Mm	Burst Pressure In Kpa
1	1.650	0.05	172.80
2	1.600	0.05	161.23
3	1.550	0.05	149.90
4	1.500	0.05	137.60
5	1.450	0.05	125.78
6	1.400	0.05	114.56
7	1.350	0.05	102.30
8	1.300	0.05	91.45
9	1.260	0.05	81.45
10	1.227	0.05	70.55

B. For Room Temperature:-

Sr. No	Membrane Thickness In Mm	Groove Depth In mm	Burst Pressure In Kpa
1	1.650	0.05	250.5
2	1.600	0.05	237.5
3	1.550	0.05	224.57
4	1.500	0.05	210.09
5	1.450	0.05	201.12
6	1.400	0.05	186.32
7	1.350	0.05	167.87
8	1.300	0.05	145.86
9	1.260	0.05	128.79
10	1.227	0.05	122.45

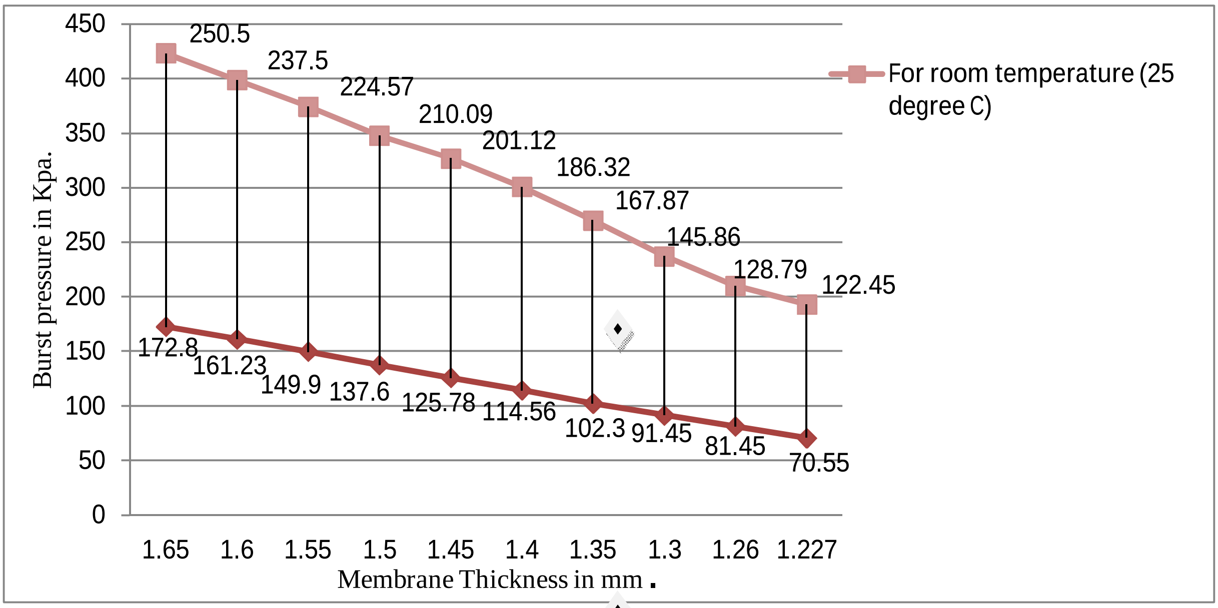

Fig.4 Thickness Vs Burst pressure graph.

C. Discussion-

Burst/Thickness test is carried out to determine the exact thickness of lead plate to safeguard the system from excess temp and pressure by bursting the lead plate at 120^0c and 100 kpa. The thickness of the plate required for bursting at 120^0 C and 100kpa from above table is 1.35 mm.by using trial and error method of both burst condition for room temperature and 120^0 C get exact condition of 120^0 temp. 1.35 m thickness,100 kpa. Pressure gets exact reading of safety condition.

VI. CONCLUSION-

The Safety membrane Device is designed to burst at a predetermined pressure of 100 kpa & at a temperature of 120 degree. Temp. & Pressure range is should be increased. .Finally after safety membrane device can provide adequate safety to Nuclear Reactors of Submarines. In Order to release the pressure to the environment, when there is any leakage in the steam carrying tubes of Nuclear reactor. There is need of more detailed study of nuclear safety device for the accident free operation of nuclear submarine .The safety membrane device .is one of them. The safety membrane devices provide adequate safety for removable shield blocks of the system by busting itself at extreme condition. Lead safety membrane device will be providing important safety parameter in nuclear safety. as it provide safety for secondary circuit of nuclear reactor of submarine. With significant changes in lead membrane design & parameters safety membrane device will be useful for other pressure vessels, boilers for their safety.

REFERENCES

[1] Yamaji And Kiyoshi Sako(Tokai Research Establishment, Japan Atomic Energy Research Institute)(July 7,2011)

[2] Grant Elliott(US Nuclear Weapon Safety and control) MIT Program in Science, Technology, and Society(Dated: December 12, 2005)

[3] Samir Yousha El-Kameesy1, Sahar Abd El- Yaser Abd Allah , 'Shielding Properties of Lead Zinc Borate Glasses'.

[4] Pichet Limsuwan and Weerapong Chewpraditkul, 'Development of Bao:B2O3:Flyash glass system for gamma-rays shielding materials' .

[5] William D Ehmann and Diane E. Vance, Radiochemistry and Nuclear Methods of Analysis, John Wiley and Sons, New York, 1991, pp 162-175.

[6] G. Nelson, D. Reilly "Gamma-Ray Interactions with Matter", in Passive Nondestructive Analysis of Nuclear Materials, Los Alamos National Laboratory, NUREG/CR-5550, LA- UR-90-732 ,1991, pp. 27-42.

[7] Edgardo Browne, Richard B. Firestone, Table of Radioactive Isotopes, Editor Virginia S.Shirley, John Wiley and Sons, New York, 1986.

[8] K. J. Singh, N. Singh, R.S. Kaundal and K. Singh, "Gamma-ray shielding and structural properties of PbO-SiO glasses," Nuclear Instruments and Methods in Physics Research B., 266, 944-948 (2008).

[9] C. P. Kaushik, R. K. Mishra, S. Kumar, B.S. Tomar, A.K. Tyagi, K. Raj and V. K. Manchanda, "Effect of barium on diffusion of sodium in borosilicate glass," Journal of Hazardous Material.,156, 129-134 (2008).

[10] B. S. Tomar, S. Kumar, V. K. Shrikhande and G. P. Kothiyal,"Study of cesium diffusion in borosilicate glass by heavy

[11] S. Kumar, R. K. Mishra, B. S. Tomar, A. K. Tyagi, C. P. Kaushik, K. Raj and V. K. Manchanda "Heavy ion Rutherford backscattering spectrometry (HIRBS) Study of barium diffusion in borosilicate glass," Nuclear Instrument and Method in Physics Research B, 226, 649-652 (2008).