2017 International Nuclear Atlantic Conference - INAC 2017
Belo Horizonte, MG, Brazil, October 22-27, 2017
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR – ABEN

Agência Brasileira do ISBN
ISBN 978-85-99141-07-6

TIME RESPONSE MEASUREMENTS OF ROSEMOUNT PRESSURE TRANSMITTERS (MODEL 3154) OF ANGRA I POWER PLANT

Roberto Carlos dos Santos[1], Iraci Martinez Pereira[1], Marcelo C. Justino[2] and Marcos C Silva[2]

[1]Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
rcsantos@ipen.br

[2]Eletrobrás Termonuclear S.A. - ELETRONUCLEAR
Departamento GLN – G
Rua da Candelária, 65 – 9º andar
20091-906 Rio de Janeiro, RJ
justino@eletronuclear.gov.br

ABSTRACT

This paper shows the Response of time five Rosemount model 3154N pressure trnasmiter from the Angra I Nuclear Power Plant. The tests were performed using the Hydraulic Ramp and Pressure Step Generator from the Sensor Response Time Measurement laboratory of CEN - Nuclear Engineering Center of IPEN. For each transmitter, damping was adjusted so that the time constant was less than or equal to 500 ms. This value has been determined so that the total value of the protection chain response time does not exceed the established maximum value of 2 seconds. For each transmitter ten tests were performed, obtaining mean values of time constant of 499.7 ms, 464.1 ms, 473.8 ms, 484.7 ms and 511.5 ms, with mean deviations 0.85%, 0.24%, 0.97%, 1.26% and 0.64% respectively.

1. INTRODUCTION

The objective of this work is to perform tests to measure the response time of five Rosemount 3154N pressure transmitters, from the Angra I Nuclear Power Plant, using the Hydraulic Ramp and Pressure Step Generator. According to the values obtained, the sensors were adjusted to provide the response time of 500ms as established in the Technical Instruction of Calibration of Transmitter Damping [1].

1.1. RESPONSE TIME - TIME CONSTANT

The term Response Time of a sensor or transmitter is a qualitative expression and can be defined as the time elapsed from the beginning of a transient to the time the sensor or transmitter records the information.

In quantitative terms, the parameter Time Constant is used, which is defined as the time required for the instrument signal to reach 63.2% of the final value after suffering a transient in the form of a step. Figure 1 below illustrates the definition of time constant.

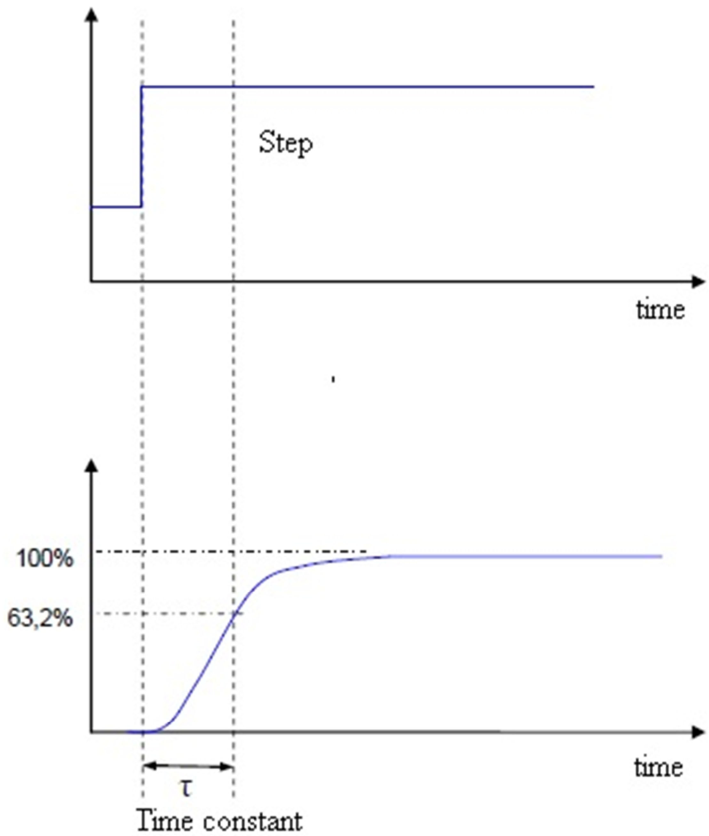

Figure 1. Definition of Time Constant

2. The Hydraulic Ramp and Pressure Step Generator

The Hydraulic Ramp and Pressure Step Generator is designed to directly measure the Response Time of pressure sensors. As the name says, it can generate pressure ramp signals, ie a slow variation of pressure in the sensor, with an intensity that can be determined by the user. It can also generate a pressure step. The Hydraulic Generator, or as it is also called, Pressure Response Time Bench, has a fast response pressure sensor, considered as a reference for the tests. The Pressure Bench has as a reference response sensor a variable reluctance transducer from Validyne Engineering Corporation, model DP15TL [2], which has a diaphragm kit so that the transducer can be used at various pressure values.

The ramp test consists of applying a ramp pressure signal to the sensor under investigation and simultaneously to the reference sensor and comparing the output responses of the two instruments, thus determining the Sensor Delay Time. The Step Test is similar to the ramp type test, with the difference that the transient is so fast that for practical purposes it can be seen as a pressure step. From the Step Test, the Sensor Time Constant is determined, which is defined as the time required for the sensor response to reach 63.2% of its final value.

2.1. Experimental Arrangement

The tests were carried out in the Laboratory of Monitoring and Diagnosis of CEN - Center of Nuclear Engineering of Ipen.

To perform the tests the following equipment was used:

- Hydraulic Pressure Generator
- High accuracy reference sensor - Validyne DP15TL
- Portable computer
- Software for data acquisition in LABVIEW
- National Instruments SB-68 Connector Block
- Power supply - Minipa MPL 3303
- HP Multimeter - 3457 A
- HP Multimeter - 3468 A
- Connecting cables

The equipment was connected according to the scheme of Figure 2, and Figure 5 shows the bench and the transmitter under analysis. The electrical signals from the reference transmitter and the measured sensor were connected to a 250 ohm resistor, and the voltage across the resistor was sent to the Data Acquisition System. Using the described experimental arrangement, tests were performed on a Positive Pressure Step, under the following conditions:

- Pressure of the compressed air that feeds the cylinders of the bench: 8 bar;
- Acquisition time of each test: 10 seconds;
- Sampling rate: 200 samples / second;

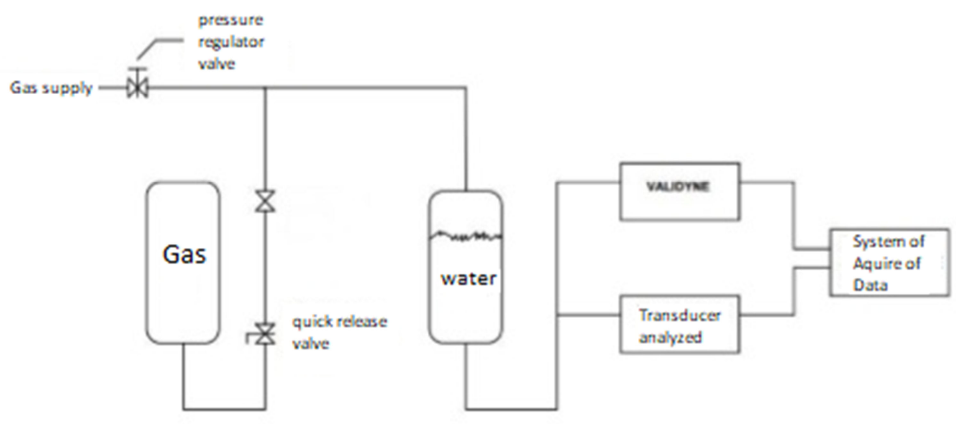

Figure 2. Experimental arrangement for Pressure Transmitter Response Time tests.

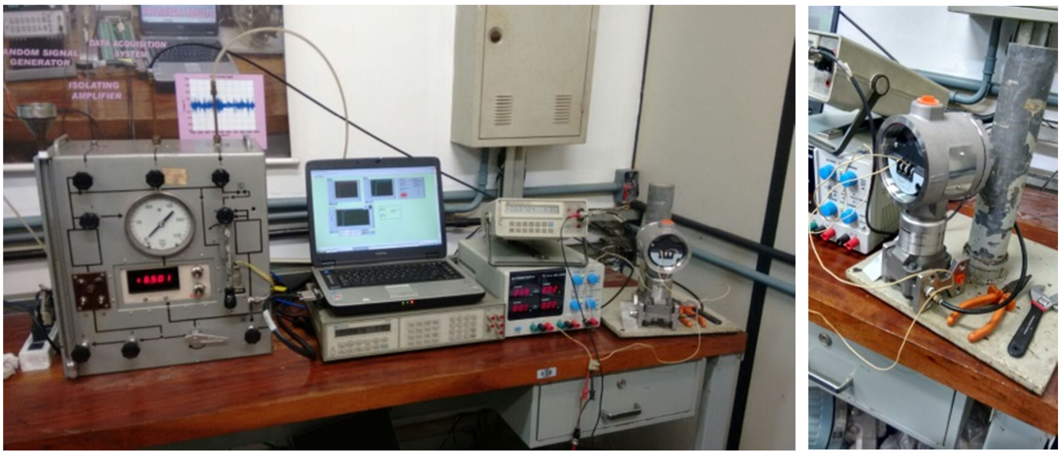

Figure 3: Pressure Transmitter Test Bench

Figure 4: High accuracy reference sensor - Validyne DP15TL

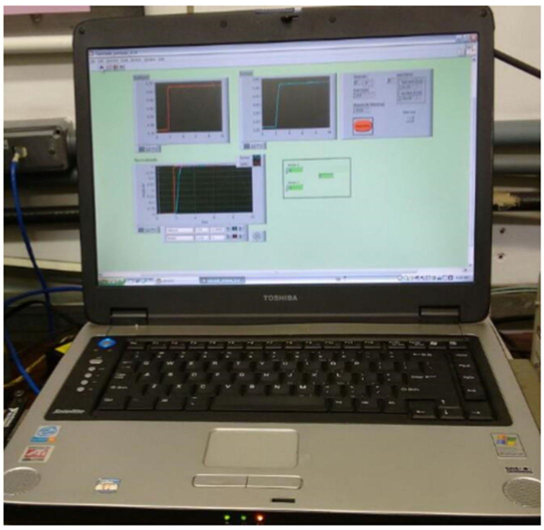

Figure 5. Interface developed in LabView for viewing and storing data

3. RESULTS

3.1. Checking the Data Acquisition Board

To perform the Response Time Measurement Tests, the data acquisition board was initially calibrated. This calibration was carried out in the Calibration Laboratory of the Angra II Nuclear Power Plant [4]. The signal from a calibrated function generator was used as input to the Data Acquisition System, consisting of the data acquisition card, notebook, data acquisition software in LABVIEW, National Instruments SB-68 connector block and connection cables. Several frequencies were used to measure the data acquisition card and the results are shown in Table 1.

Table 1. Results of the measurement of the data acquisition card.

frequency applied (Hz)	frequency measurement (Hz)
5	5,0000
10	10,0000
4	4,0000
2,2	2,2026
2,1	2,1008
2	2,0040
1,9	1,9048
1,8	1,7986
1,8	1,7986
1	1,0010
0,5	0,5000

3.2. Preliminary Results - minimum and maximum damping

In models of 3154N pressure transmitters the damping time adjustment is performed simply by varying a potentiometer [1]. The location of the potentiometer is shown in Figure 6 below, where it can be seen that this setting can vary from a minimum value (MIN) to a maximum value (MAX).

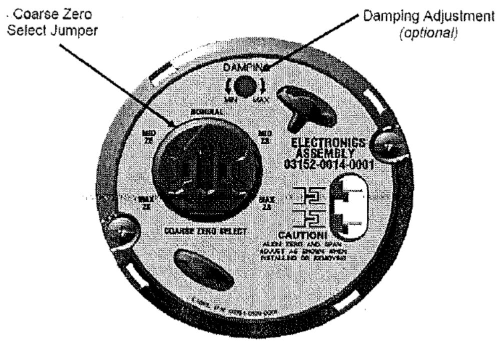

Figure 6. Damping adjustment potentiometer.

Initially, preliminary tests were performed to determine the value of the transmitter's initial time constant without changing the damping setting. Note that the potentiometer of all transmitters received was in the minimum damping position. In addition, for each of the transmitters tests were made with the damping adjustment potentiometer in the maximum position.
The results of the tests performed are shown in Table 2.

Table 2. Time constant for minimum and maximum damping adjustment.

	Time constant (seconds)									
	Transmitters **01**		Transmitters **02**		Transmitters **03**		Transmitters **04**		Transmitters **SPARE**	
damping	**min**	**máx**	**min**	**máx**	**min**	**máx**	**min**	**máx**	**min**	**máx**
teste1	0,3251	1,7346	0,3172	1,5647	0,2690	1,5603	0,2687	1,7977	0,2743	1,0845
teste2	0,3278	1,7479	0,3112	1,5746	0,2644	1,5878	0,2673	1,7983	0,2651	1,1014
teste3	0,3237	1,7523	0,3143	1,5716	0,2693	1,5991	0,2643	1,7714	0,2516	1,1157
teste4	0,3266	1,7378	0,3125	1,5746	0,2673	1,6051	0,2750	1,7811	0,2520	1,1039
teste5	0,3164	1,758	0,3113	1,5770	0,2697	1,6145	0,2837	1,7675	0,2335	1,1045
média	0,3239	1,7461	0,3133	1,5725	0,2679	1,5934	0,2718	1,7832	0,2553	1,1020
desvio médio %	0,96	0,456	0,63	0,22	0,62	0,97	2,22	0,66	4,51	0,66

3.3. Setting results for 500 ms

For each transmitter, several initial measurements were made in order to determine the value of the time constant. If the measured value were outside the required value of 500 ms, the damping adjustment potentiometer was modified. This procedure was repeated until the desired value was reached. With the potentiometer adjusted, the measurements were repeated 10 times for each transmitter, for a good statistic. Figure 7 following is an example of a result of the response time to a test pressure to Step five transmitters.

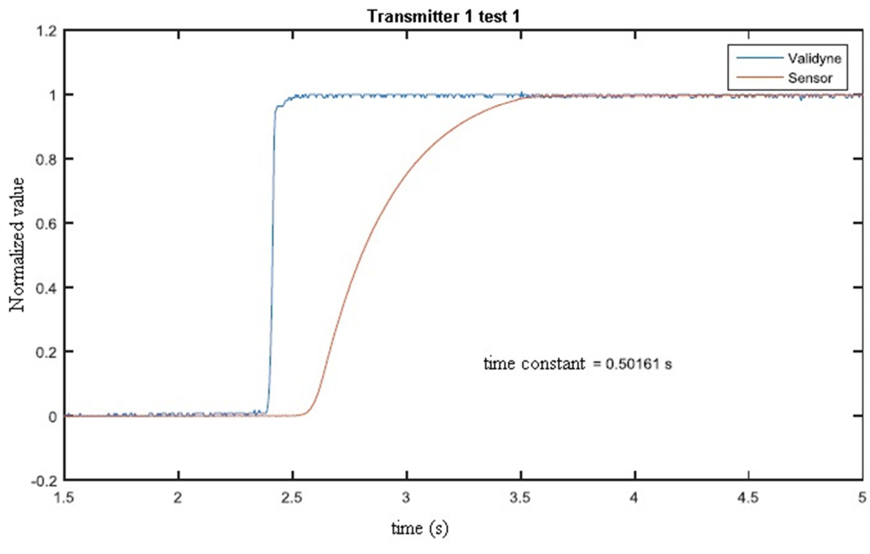

Figure 7: Representative graphic of the tests

Table 3 shows the time constant values calculated for each sensor, and for each of the 10 tests performed. The mean value of the time constant and the corresponding mean deviation were calculated.

Table 3. Time constant calculated from the Response Tests to a Pressure Step

	Time constant (seconds)				
	Transmitters 01	**Transmitters 02**	**Transmitters 03**	**Transmitters 04**	**Transmitters SPARE**
teste1	0,5016	0,4629	0,4948	0,4812	0,4981
teste2	0,5041	0,4649	0,4738	0,4779	0,5148
teste3	0,4932	0,4656	0,4702	0,4781	0,5157
teste4	0,4939	0,4638	0,468	0,4769	0,5159
teste5	0,4976	0,4631	0,4685	0,4854	0,5126
teste6	0,501	0,4618	0,4756	0,4904	0,513
teste7	0,5014	0,4634	0,4682	0,4813	0,5115
teste8	0,5082	0,4645	0,4715	0,5078	0,5106
teste9	0,4931	0,4655	0,4733	0,4824	0,5135
teste10	0,5032	0,4655	0,4738	0,486	0,5095
mean	0,4997	0,4641	0,4738	0,4847	0,5115
mean deviation %	0,85	0,24	0,97	1,26	0,6

4. CONCLUSIONS

Measurements of the time constant of five Rosemount model 3154N pressure transmitters were made. For each transmitter, damping was adjusted so that the time constant was less than or equal to 500 ms. This value has been determined so that the total value of the protection chain response time does not exceed the established maximum value of 2 seconds. After the damping adjustments were made, the tests presented excellent repeatability, as can be seen in Table 2.

REFERENCES

1. Technical Instruction of Transmitter Damping Calibration Rosemount Model 3154N; IN-A1-0111 (SRR04074848); Marcelo de Castro Justino; Eletronuclear, June 2016.

2. Validyne DP15TL Pressure Sensor Kit for Changing Ranges; http://validyne.com/product/DP15TL_Pressure_Sensor_Kit_for_Changing_Ranges#sthash.rocvtOEn.dpbs

3. Data Acquisition Board NI AT-MIO-16E-2500 kS/s, 12-Bit, 16 Analog Input Multifunction DAQ; disponível em: http://sine.ni.com/nips/cds/view/p/lang/pt/nid/11919

4. Attestation of Calibration - Calibration nº 559/2017 - Laboratory of Calibration and Tools - LFC. Instrument: Data acquisition board model DAQ CARD- 6024E, manufacturer: National Instruments