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CASE STUDY

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Title:
Everything Counts in Large Amounts – Creating an Innovative Creep Test System

Author:
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Industry:
Industrial Control, Energy

Products:
National Instruments (NI) LabVIEW, NI FPGA, NI Real-Time

The Challenge:
Develop a complete control and data acquisition system for a materials test system that studies creep in up to 36 specimens at varying temperatures, stresses and loading profiles.

The Solution:
Signal.X Technologies created a control system based on LabVIEW Real-Time and utilizes distributed I/O, high-speed closed loop control in FPGA and a flexible and intuitive user interface and configuration application.

Overview:
Gas Technology Institute (GTI) is a leading research, development and training organization that addresses energy and environmental challenges to enable a secure, abundant and affordable energy future. One aspect of GTI's research is the development and validation of testing methodologies for polyethylene pipe typically used in natural gas distribution.

The common failure mode for these pipes is slow crack growth, in which stress concentrations build up and cracks grow from material creep. GTI contracted Signal.X to develop a control and data acquisition application for a test system to measure this material property in polyethylene pipe samples. This application would have to run long-duration tests on up to 36 samples at a time, all running independent test profiles, while maintaining tight control over the loading and measuring the creep precisely over time.

Hardware Description:
This project used a distributed model for control that leverages the power of the FPGA Ethernet expansion chassis to control the test and collect data. The test system includes 4 temperature chambers with 9 samples in each chamber for a total of 36 independent samples. Each temperature chamber is controlled with a single

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expansion chassis and all the data is collected at a single NI 3100RT industrial controller running LabVIEW Real-Time.

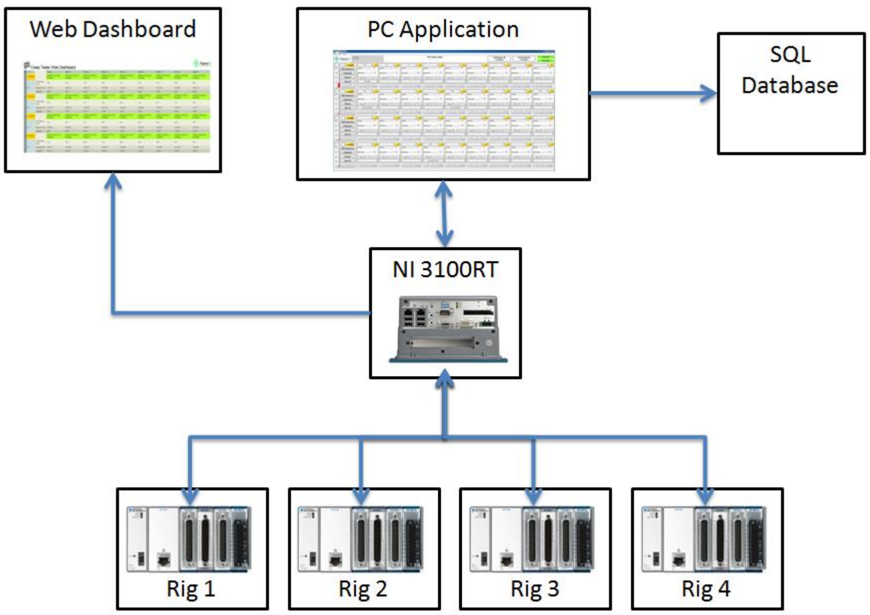


Figure 1: System functional diagram

Test Control:
Due to the unique nature of this test setup, GTI needed a high level of flexibility for the test and sample setup. It begins with the terminology of the test sequence, which is made up of an equation that combines one or more test profiles. Each profile consists of one or more blocks, which is the lowest level of test step. This flexibility supports a combination of static testing (the typical way of measuring creep) and cyclic testing to accelerate sample degradation and failure. If desired, temperature can be controlled through triggers that support warm-up timing, synchronized sample starting and cyclic temperature profiles.

The Real-Time controller is responsible for executing the test sequence and sending setpoints to the FPGA at the Ethernet expansion chassis. Signal.X used its proven multi-channel PID control algorithm with bumpless transfer and derivative filtering for this application to enable smooth application of pressure on the samples.

Data Acquisition:
GTI required accurate timing and data acquisition on all samples to match experimental strain data to the theoretical curves based on the materials' properties. All data from the test is logged in the NI-standard TDMS

format by the Real-Time controller at configurable rates, then uploaded to the PC and ultimately stored in a laboratory database that ensures easy access to the data for comparison and validation.

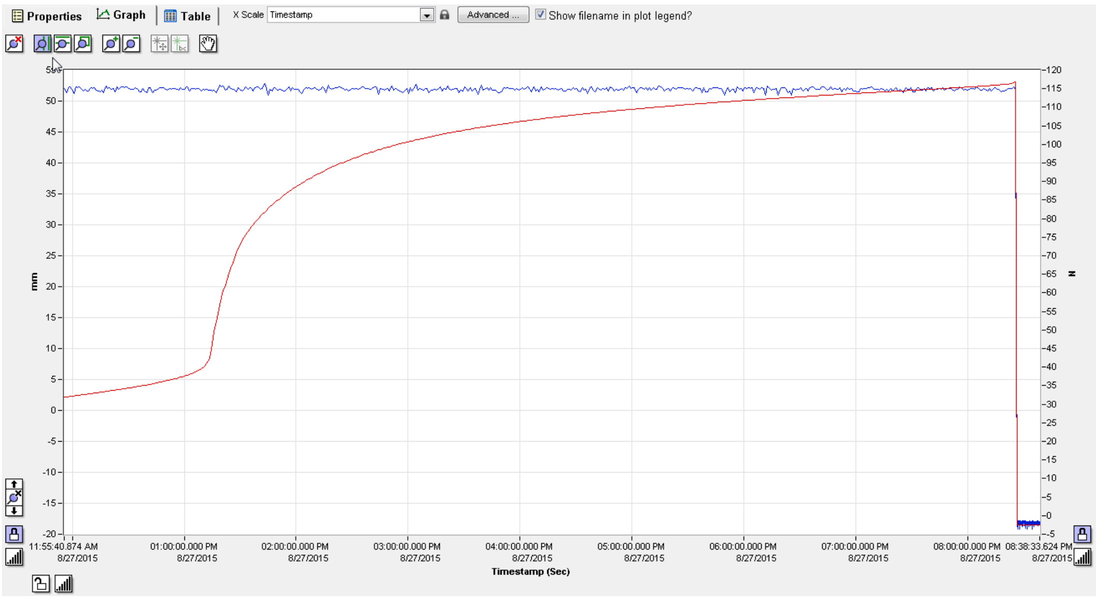


Figure 2: Plot of data collected by the system, both displacement and load

Operator Interface:
With as many as 36 tests in process simultaneously, clear and easy access to data, test status and configuration information is critical to the effectiveness of the program and the efficiency of the operators using the software. The primary interface is a single grid showing the test status and basic data for all samples, with a detail screen available for each sample.

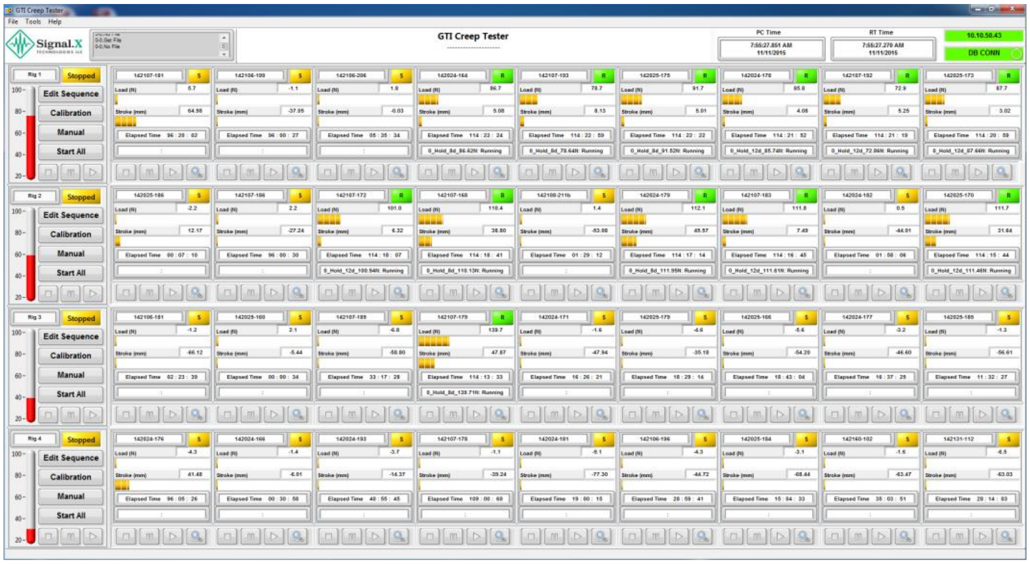
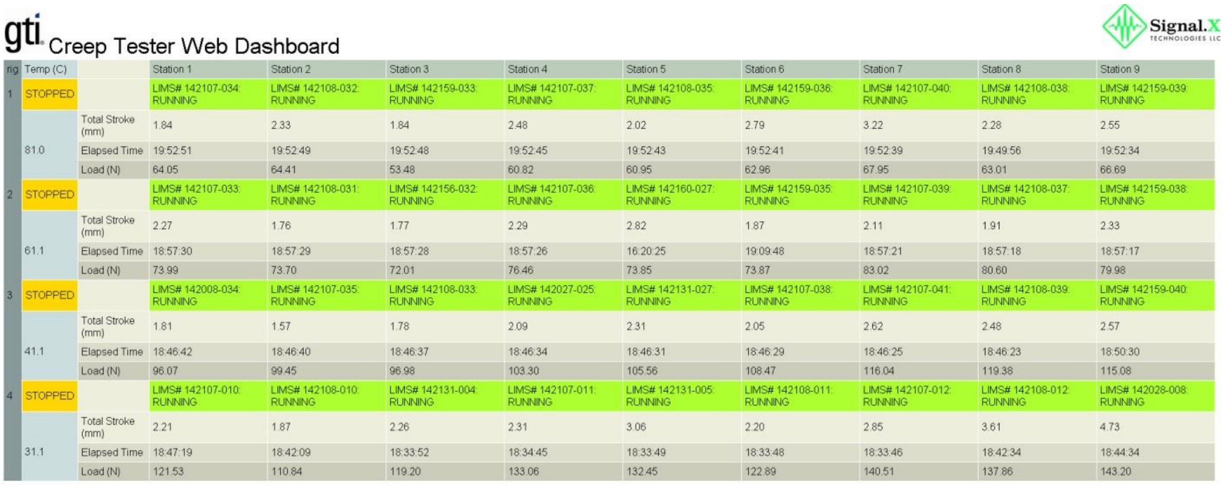


Figure 3: Main PC interface

The PC interface is complemented by a web-based status screen hosted by the Real-Time controller that is accessible from anywhere within the GTI Intranet.



gti Creep Tester Web Dashboard

rig	Temp (C)		Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9
1	STOPPED		LIMS# 142107-034: RUNNING	LIMS# 142108-032: RUNNING	LIMS# 142159-033: RUNNING	LIMS# 142107-037: RUNNING	LIMS# 142108-035: RUNNING	LIMS# 142159-036: RUNNING	LIMS# 142107-040: RUNNING	LIMS# 142108-038: RUNNING	LIMS# 142159-039: RUNNING
		Total Stroke (mm)	1.84	2.33	1.84	2.48	2.02	2.79	3.22	2.28	2.55
	81.0	Elapsed Time	19:52:51	19:52:49	19:52:48	19:52:45	19:52:43	19:52:41	19:52:39	19:49:56	19:52:34
		Load (N)	64.05	64.41	53.48	60.82	60.95	62.96	67.95	63.01	66.69
2	STOPPED		LIMS# 142107-033: RUNNING	LIMS# 142108-031: RUNNING	LIMS# 142156-032: RUNNING	LIMS# 142107-036: RUNNING	LIMS# 142160-027: RUNNING	LIMS# 142159-035: RUNNING	LIMS# 142107-039: RUNNING	LIMS# 142108-037: RUNNING	LIMS# 142159-038: RUNNING
		Total Stroke (mm)	2.27	1.76	1.77	2.29	2.82	1.87	2.11	1.91	2.33
	61.1	Elapsed Time	18:57:30	18:57:29	18:57:28	18:57:26	16:20:25	19:09:48	18:57:21	18:57:18	18:57:17
		Load (N)	73.99	73.70	72.01	76.46	73.85	73.87	83.02	80.60	79.98
3	STOPPED		LIMS# 142008-034: RUNNING	LIMS# 142107-035: RUNNING	LIMS# 142108-033: RUNNING	LIMS# 142027-025: RUNNING	LIMS# 142131-027: RUNNING	LIMS# 142107-038: RUNNING	LIMS# 142107-041: RUNNING	LIMS# 142108-039: RUNNING	LIMS# 142159-040: RUNNING
		Total Stroke (mm)	1.81	1.57	1.78	2.09	2.31	2.05	2.62	2.48	2.57
	41.1	Elapsed Time	18:46:42	18:46:40	18:46:37	18:46:34	18:46:31	18:46:29	18:46:25	18:46:23	18:50:30
		Load (N)	96.07	99.45	96.98	103.30	105.56	108.47	116.04	119.38	115.08
4	STOPPED		LIMS# 142107-010: RUNNING	LIMS# 142108-010: RUNNING	LIMS# 142131-004: RUNNING	LIMS# 142107-011: RUNNING	LIMS# 142131-005: RUNNING	LIMS# 142108-011: RUNNING	LIMS# 142107-012: RUNNING	LIMS# 142108-012: RUNNING	LIMS# 142028-008: RUNNING
		Total Stroke (mm)	2.21	1.87	2.26	2.31	3.06	2.20	2.85	3.61	4.73
	31.1	Elapsed Time	18:47:19	18:42:09	18:33:52	18:34:45	18:33:49	18:33:48	18:33:46	18:42:34	18:44:34
		Load (N)	121.53	110.84	119.20	133.06	132.45	122.89	140.51	137.86	143.20

Figure 4: Web dashboard

The Bottom Line:
Signal.X created a unique software application that provided a cutting-edge platform for research and development for both the materials used in critical pipeline infrastructure as well as the testing methodology

for those materials. The combination of LabVIEW, Real-Time and FPGA supported a reliable, flexible and effective development process.

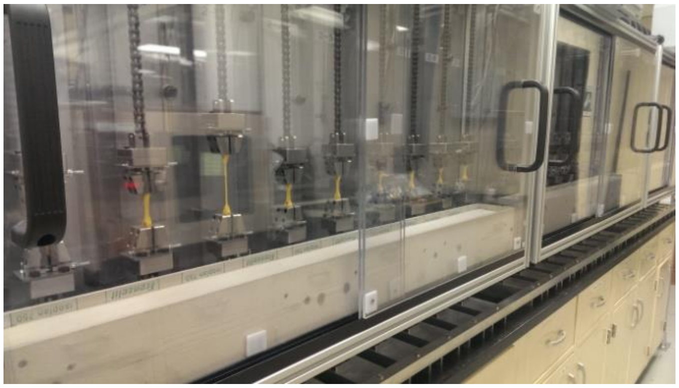


Figure 5: Creep tester samples on test

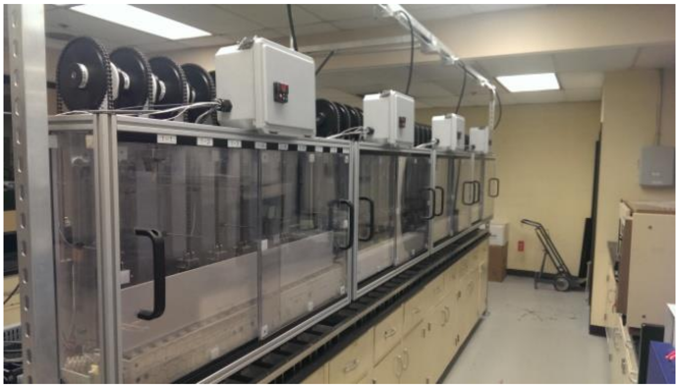


Figure 6: All four chambers of the creep tester

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