IMPROVE PRIMARY CONTROL USING REALTIME DYNAMIC PROCESS CONTROL SIMULATOR

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The term "primary process control" generally refers to the control of flow in a pipe, level in a tank, process temperature, pressure and other process variables in a chemical plant. The popular PID (proportional, integral and derivative) control algorithm performs over 95% of primary control in today's chemical industry.

Despite being branded sometimes as "archaic" and "too-simple", the PID's existence sees little threat from new high-tech control algorithms. The PID's simplicity, reliability and robustness, coupled with its forgiving nature against misuse with poor tuning constants has rendered entry of new alternative control algorithms difficult.

With relentlessly increasing pressures on profitability, survivability in a brutally competitive global environment, premier oil-and-gas and chemical companies have resorting to improved process control as one of the powerful methods to maximize their profits and outdo their competition. Established and accepted process control concepts include:

- Equipping all chemical plants with modern DCS and PLCs.
- Control primary process variables with PIDs.
- Apply multivariable and advanced control strategies such as MPC (model predictive control), rule-based control, online optimizers where meaningful and appropriate.

New plants all come with DCS and PLCs. Plant management aggressively plans to implement various types of advanced control strategies to maximize the plant's operating profit margin. Unfortunately, industry studies show that many plants continually suffer with less than optimal control performance of the primary control PIDs. Oscillatory ripples caused by inappropriate PID tuning, control valve problems and avoidable interactive disturbances continue to plague the primary control performance. Poor primary control performance can cost a plant anywhere from several hundred thousand dollars to several millions due to lost production capacity, poor product quality control and needlessly high utility usage. Furthermore, poor primary control performance will cripple higher level advanced control and optimization systems and severely reduce their potential monetary benefits.

PLC and DCS systems engineers receive formal and adequate training from DCS and PLC vendors. They are well equipped with knowledge, skills and tools to install and maintain the hardware. Instrument technicians receive good training to take care of their instruments. Advanced control specialists responsible for installing MPC and online optimizer type high-tech products are also known to receive proper training and skills to do their jobs effectively. In surprising contrast, industry study shows that PID tuning, maintenance and PID control quality monitoring surprisingly remain grossly neglected and severely under-emphasized.

Many plant technicians and process control engineers never receive adequate training on PID tuning and maintenance. They are caught-up with day-to-day "urgent" items such as adding new control schemes, modifying operator graphics, alarm limits and other mundane chores. Amidst the busy life of a control engineer or DCS-PLC technician, PID control suffers and noticeably impacts the overall plant performance and profits. In an era of modern high-tech tools, computers and engineering specialists, one can ask why the PID and primary control negligence is so commonplace. The reasons are many and diverse:

- Poorly tuned PIDs can still easily allow the plant to operate at nameplate or higher capacities. What is a missed opportunity is that an optimally tuned plant can make much more - as much as 2-7% extra capacity and this is in addition to benefits from higher level advanced control strategies like MPC and optimization.
- While a failed instrument or a failed pump must be repaired to allow the plant to run, a badly tuned primary PID appears harmless - the oscillations and poor control response does not intuitively or obviously seem to be costing money or causing any harm. In reality, the impact on the overall plant performance because of a few poorly performing PIDs can be shocking high.
- Fresh college graduates understand Laplace and Z-domain control theory well, but are ill prepared to confront needs in the very practical, non-academic type control-room environment.
- DCS-PLC technicians well trained on the basics of how the PID works have little opportunity for mastering tuning skills because of unavailability of simulators for tuning training practice.
- Many just opine that PID is too simple, too mundane. They would rather focus their attention and energy on high-tech control tools than worry about the age-old PID that is supposed to "work well easily all the time by itself".

Control engineers and DCS-PLC technicians need to be formally trained on practical process control catering to the control room needs and environment. They should be provided with a real-time simulator on which they can practice tuning in a very real plant-like environment. They should have the freedom and ability on a control simulator to fearlessly drive loops unstable, study sluggish control, valve problems and the effect of external unmeasured disturbances on control quality.

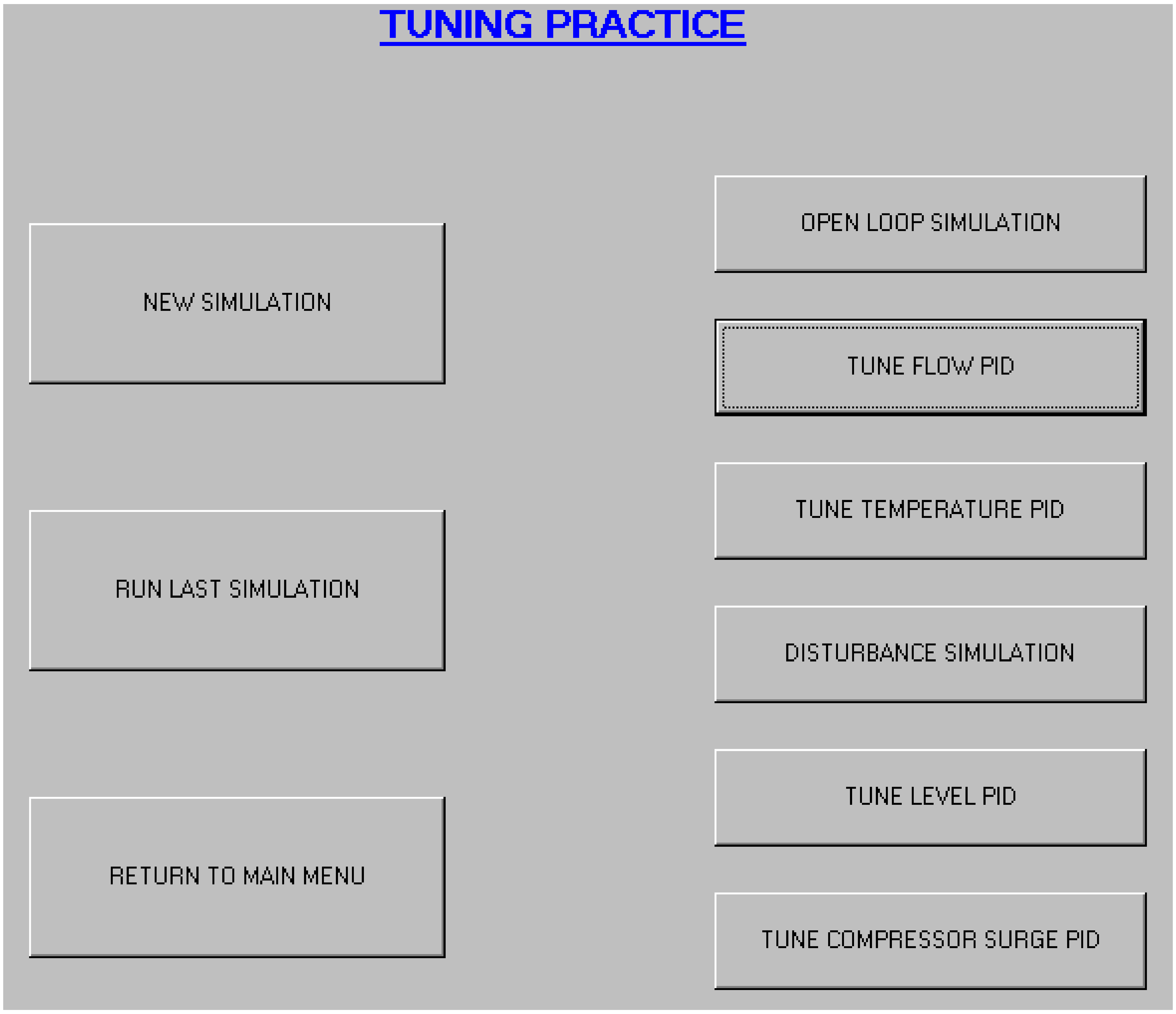
The plant's operating performance can be impacted significantly and noticeably by the choice of tuning parameters. Authorized persons bestowed with control room tuning privileges ought to be trained, qualified and certified based on testing on a simulator. Simulator-based training, practice time and then testing not only improves tuning skills but also helps the engineer or technician to identify control and instrumentation problems that earlier seemed too subtle and elusive.

To address this current gap and facilitate training and certification of control engineers and technicians, Artcon, LLC developed a new modern real-time dynamic simulator called Simcet^{TM}. Simcet^{TM} provides two main features:

- Real-time practice environment on the PC for the user to configure PID loops, change setpoints, examine response to fast random noise, slow drifts and disturbances mimicking the real plant environment. Simcet^{TM} includes canned (pre-configured) practice simulations on FC, PC, LC, TC, AC and compressor controls.
- Testing feature to test his/her tuning skills and capability. Twelve tests randomly generated (different test each time) cover FC, PC, LC, TC, AC and compressor controls. Each test is graded based on the user's final P, I, D and filter time constant and also based on time taken by the user to complete each test.

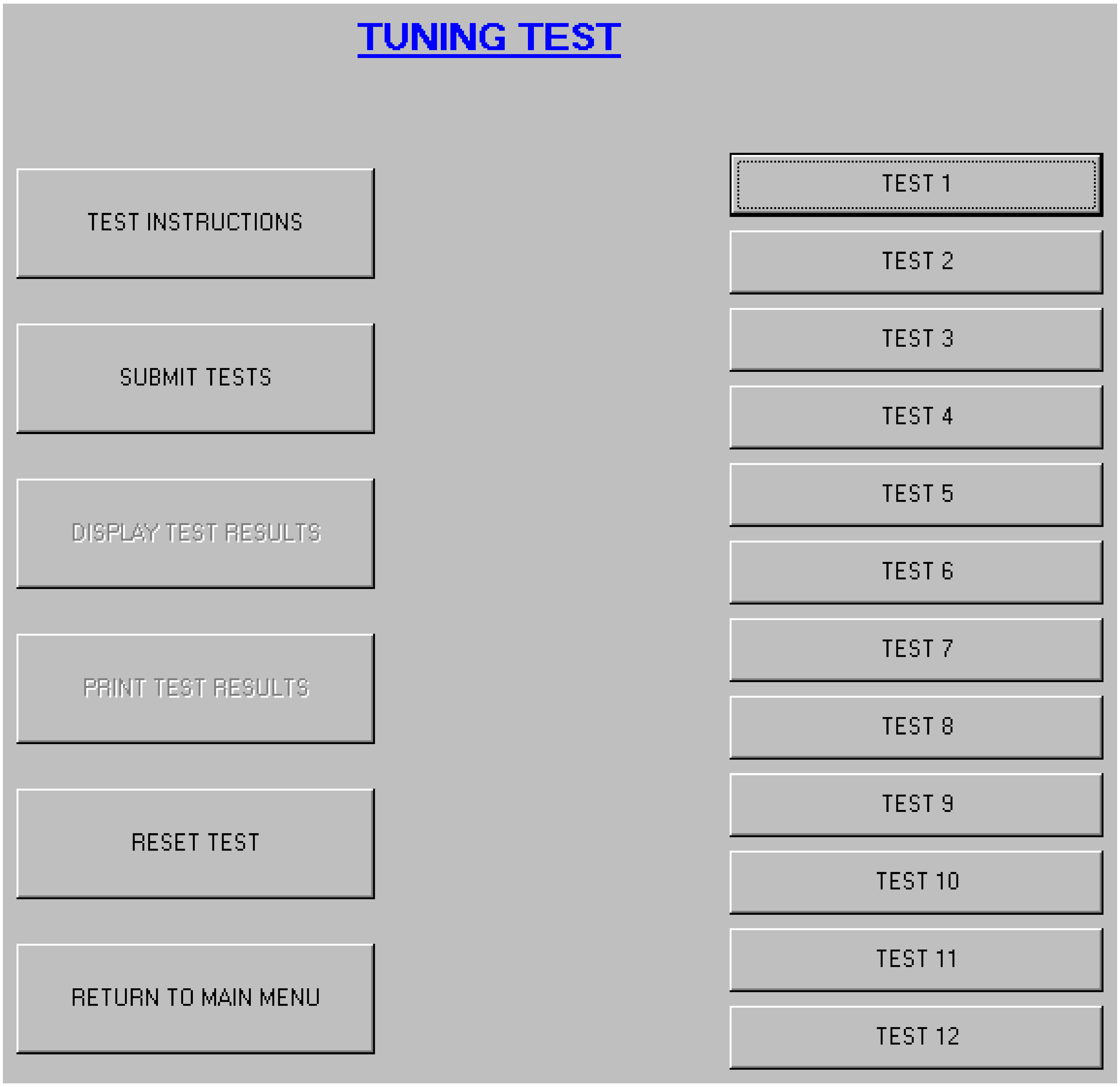
Figure 1 shows the tuning practice menu and Figure 2 shows the testing menu in Simcet^{TM}.

Figure 1. Simcet^{TM} Tuning Practice Menu



During practice sessions, the user can click on any of the canned loops for simulating FC, TC, LC, compressor loops or configure any custom process dynamics to mimic his plant by specifying first/second order transfer function parameters. The user can change setpoints like in the real plant DCS, add random noise to mimic electronic noise in flowmeters, add slow disturbances by configuring a complex disturbance composite comprising of repeating pulses, ramps and sinusoidal waves of different amplitudes and frequencies. A typical simulation is shown in Figure 3.

Figure 2. Simcet™ Tuning Test Menu



In the simulation, user has made several setpoint changes. The user made the control action unstable in two places, once by high proportional action and in the second case by high integral action. Notice that a very real plant-like disturbance signal comprising of both random noise and unknown drifts make the simulation look very real.

Simcet™ provides numerous other features, virtually all features seen on the real DCS or PLC system in the control room. Some of these features are choice of numerous PID control equation types, gap action control, PV sample delay to simulate analyzer sample (hold) times and filter action.

Figure 3. Simcet^{TM} Simulation Screen

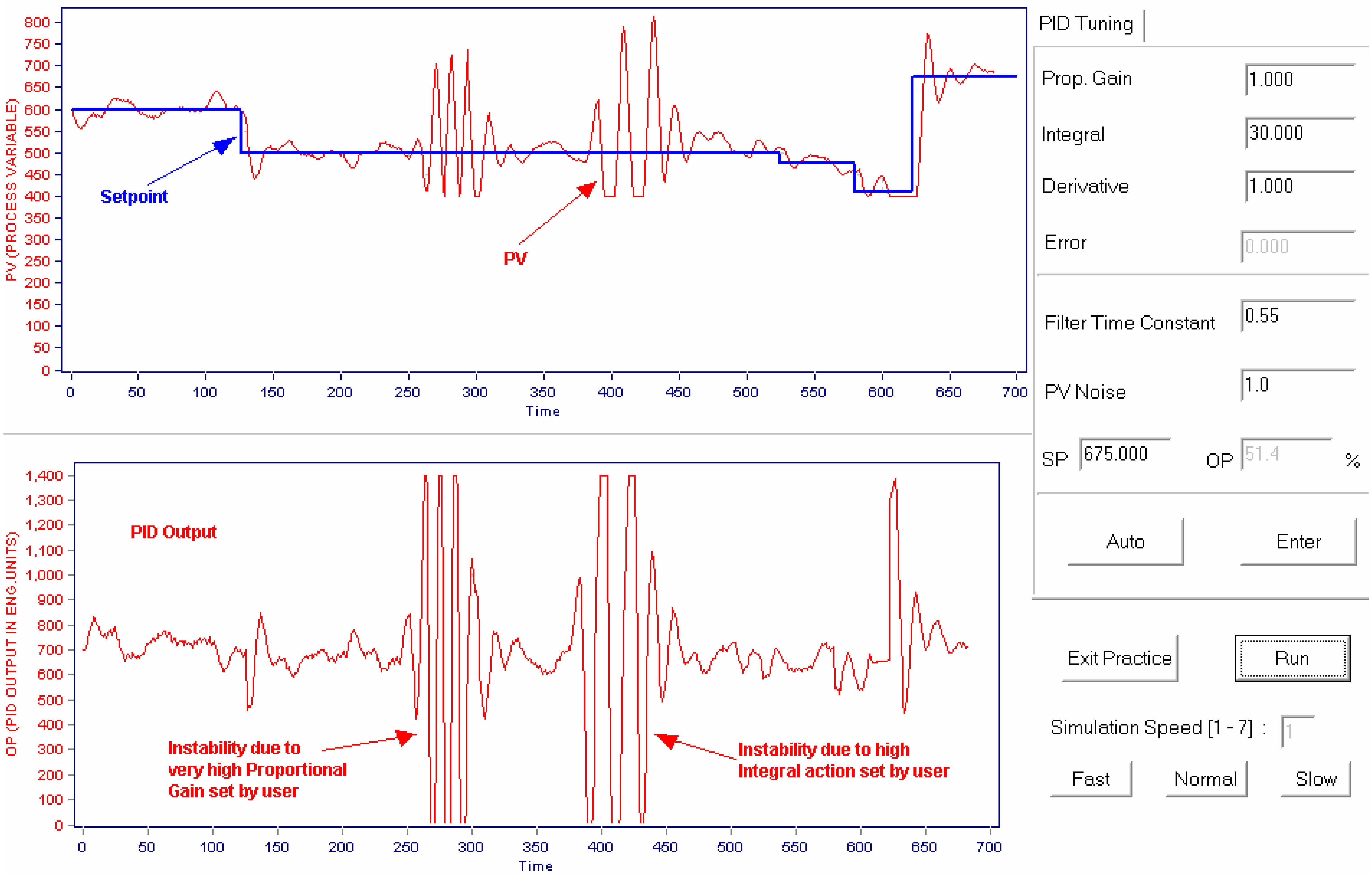
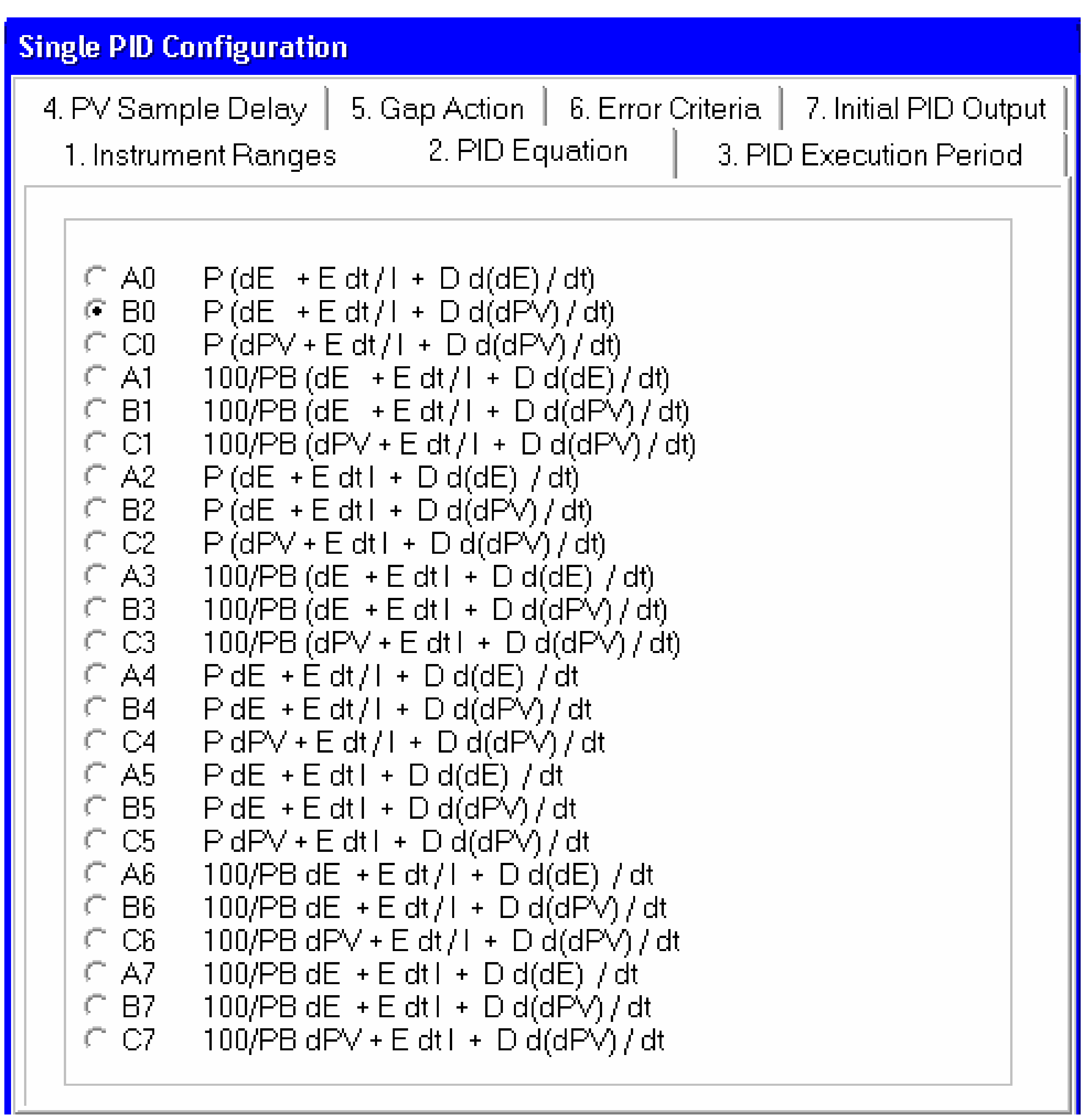
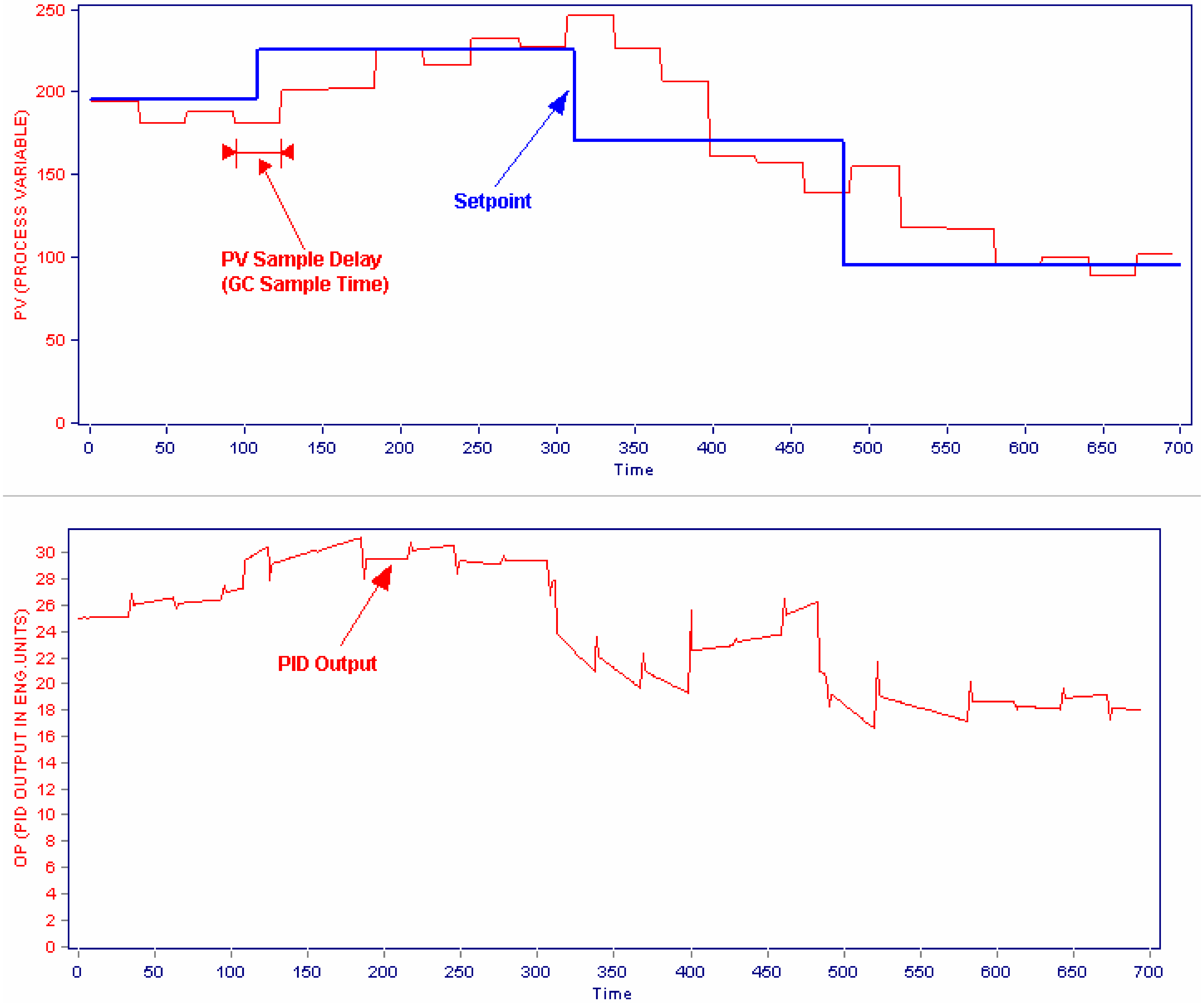


Figure 4. Simcet^{TM} PID Equation and Configuration



One of the important money-saving control schemes is the use of online analyzers for the control of product purities. Gas chromatographs (GCs) may need 5-30 minutes typically for sending a new sample reading. This delay manifests as the flat PV lines shown in Figure 5, illustrating control action in the presence of PV sample delay, characteristic in analyzers. Such type of simulations provide the user with a wide array of exposure to a variety of control schemes to provide quality tuning training.

Figure 5. Simulation of GC Sample Hold Time in Simcet™



After the user has completed all canned practice sessions and custom simulations configured to match the real process, the user is then ready to take the tuning tests. The testing part of Simcet™ provides up to twelve tests for the user to take. The twelve tests consist of different types of loops - FC, LC, PC, TC, AC and UC. Tests are randomly generated; if the user repeats the test, different tests are generated every time. After completion of all tests, a display form shows the overall performance and individual loop performance. The score for each test is based on comparison between the optimal P, I, D, filter-constant tuning parameters and also based on the time taken to complete the test. The final score sheet is shown in Figure 6.

Figure 6. Simcet™ Test Result Score Sheet

Test Results

TEST	P BEST	P USER	I BEST	I USER	D BEST	D USER	F BEST	F USER	SCORE
TEST 1	0.97	3.00	12.00	35.00	0.00	0.00	2.00	4.00	74.41
TEST 2	40.00	3.00	50.00	20.00	0.00	2.00	0.00	0.00	54.90
TEST 3	11.00	2.00	30.00	25.00	0.60	1.00	1.00	1.00	75.31
TEST 4	2.00	3.00	350.00	45.00	2.20	0.00	3.00	2.00	61.11
TEST 5	8.00	4.00	16.00	50.00	1.10	0.00	0.00	0.00	70.06
TEST 6	15.00	3.00	30.00	100.00	0.00	0.00	0.00	0.00	58.79
TEST 7	9.00	3.00	90.00	140.00	0.00	2.00	0.00	0.00	75.30
TEST 8	7.00	2.00	120.00	35.00	0.00	0.00	0.00	0.00	74.86
TEST 9	5.00	5.00	10.00	55.00	0.60	0.10	0.00	0.00	76.31
TEST 10	2.00	3.00	15.00	75.00	1.00	0.00	0.00	0.00	79.13
TEST 11	1.30	2.00	55.00	35.00	0.00	0.00	0.00	0.00	89.63
TEST 12	3.70	5.00	20.00	20.00	0.00	0.00	0.00	0.00	97.02

OVERALL SCORE 73.90

CLOSE

Industry is increasingly looking towards easy to use, low cost, off-the-shelf process control software products. Simcet's interface is as easy as it can get with minimal screens and minimal user entry. At an attractive cost, the user has a full-blown simulator in his office, control room or home, a value and service unmatched by any other company.

Over the years, increasingly tighter government and other regulations have resulted in more and more companies requiring training their employees annually on a variety of topics. These topics include safety, ergonomics, on-the-job hazards, process technology and operations. It is expected that formal training on PID tuning will become a standard testing requirement in the next few years. Artcon, LLC has taken the initiative to spearhead this testing to assist the chemical industry to train and develop better control engineers and technicians. Results show that this will help the plants to operate more efficiently and maximize their performance and profits and stay competitive in the global economy.