Oil & Natural Gas Technology

DOE Award No.: DE-FE0023919

Quarterly Research Performance Progress Report (Period Ending 09/30/2016)

Deepwater Methane Hydrate Characterization and Scientific Assessment

Project Period 10/01/2014 – 09/30/2020

Submitted by:
Peter B. Flemings

Signature

The University of Texas at Austin
DUNS #:170230239
101 East 27th Street, Suite 4.300
Austin, TX 78712-1500
e-mail: pflemings@jsg.utexas.edu

Office of Fossil Energy

1. ACCOMPLISHMENTS:

A. What are the major goals of the project?

The goals of this project are to plan and execute a state of the art field program in the Gulf of Mexico to characterize methane hydrates. The project team will acquire conventional core, pressure core, and downhole logs, and perform in situ testing and measure physical properties in methane hydrate reservoirs in the Gulf of Mexico (GOM) to meet this goal.

Previous Phase Milestones

Milestone Description	Status
M1A: Project Management Plan	Complete: 03/18/2015
M1B: Project Kick-off Meeting	Complete: 12/11/2014
M1C: Site Location and Ranking Report	Complete: 9/30/2015
M1D: Preliminary Field Program Operational Plan Report	Complete: 9/30/2015
M1E: Updated CPP Proposal Submitted	Complete: 10/1/2015
M1F: Demonstration of a viable PCS Tool	Complete: 9/30/2015

Table 1: Milestones BP1

Current Phase Milestones

Milestone Description	Status	Verification Method	Comments
M1G: Document results of BP1/Phase 1 Activities	Submitted	Phase 1 Report	
M2A: Complete Updated CPP Proposal Submitted	Complete: Nov 2015 (BP3, Q1)	Quarterly Report	Update given in Y2Q1 report
M2B: Scheduling of Hydrate Drilling Leg by IODP	Expected date: May 2017 (BP2, Q7)	report status immediately to DOE PM	
M2C: Demonstration of a viable PCS tool for hydrate drilling through completion of land-based testing	Complete: Dec 2015 (BP2, Q5)	PCTB Land Test Report, in Quarterly Report	Update given in Y2Q1 report
M2D: Demonstration of a viable PCS tool for hydrate drilling through completion of a deepwater marine field test	Expected date: March to May 2017 (BP2, Y2)	Marine Field Test Report, in Quarterly Report	
M2E: Complete Refined Field Program Operation Plan	Expected date: Sept 2017 (BP2, Q8)	Quarterly Report	

Table 2: Milestones BP2

Future Phase Milestones

Milestone Description	Planned Completion	Verification Method
M2F: Document results of BP2/Phase 2 Activities	12/29/2017 (BP3A, Q1)	Phase 2 Report
M3A: Field Program Operational Plan report	12/18/2018 (BP3A, Q5)	Quarterly Report
M3B: Completion of Field Program Permit	12/9/2018 (BP3A, Q5)	Quarterly Report
M3C: Completion of Hazards Analysis	10/9/2018 (BP3A, Q5)	Field Program Hazards Report, in Quarterly Report
M3D: Demonstration of a viable PCS tool for hydrate drilling through completion of field operations	4/4/2019 (BP3A, Q7)	Quarterly Report
M3E: Complete IODP Preliminary Expedition Report	6/27/2019 (BP3A, Q7)	Send directly to DOE PM
M3F: Complete Project Sample and Data Distribution Plan	8/8/2019 (BP3A, Q8)	Send directly to DOE PM
M3G: Initiate Expedition Scientific Results Volume	4/3/2020 (BP3B, Q3)	Send directly to DOE PM
M3H:Complete IODP Proceedings Expedition Volume	8/24/2020 (BP3B, Q4)	Send directly to DOE PM

Table 3: Milestones BP3A, and BP3B

B. What was accomplished under these goals?

PREVIOUS – BUDGET PERIOD 1:

Task	Status	Quarterly Report with Task Information
Task 2.0 Site Analysis and Selection	Complete	Y1Q1, Y1Q2, Y1Q3, Y1Q4
Task 3.0 Develop Pre-Expedition Drilling/Logging/Coring/Sampling Operational Plan	Complete	Y1Q3, Y1Q4
Task 4.0 Complete and Update IODP CPP Proposal	Complete	Y1Q2, Y1Q3, Y1Q4
Task 5.0 Pressure Coring and Core Analysis System Modification and Testing	Complete	Y1Q2, Y1Q3, Y1Q4

CURRENT - BUDGET PERIOD 2:

Task 1.0 Project Management and Planning (*Status: On Schedule)*

Activity this period:

Objectives and Achievements
Objective 1: Assemble teams according to project needs.

- Recruited for postdoctoral position, research associate, and mapping technician
  - o Conducted interviews
  - o Made offers
  - o On boarded contract mapping technician

Objective 2: Coordinate the overall scientific progress, administration and finances of the project

- Managed current tasks see details in document below
- Monitored costs reported status and changes to DOE project manager

Objective 3: Communicate with project team and sponsors

- Organized regular team meetings
- Held Marine Test kick off meeting in Houston
- Managed SharePoint sites, email list, and archive/website

Objective 4: Coordinate and supervise all subcontractors and service agreements to realize deliverables and milestones according to the work plan

- Actively managed subcontractors and service agreements.
- Still in negotiations on SOW and budget for University of New Hampshire subcontract.

Objective 5: Compare identified risks with project risks to ensure all risks are identified and monitored. Communicate risks and possible outcomes to project team and stakeholders.

- Actively monitored project risks and as needed reported to project team and stakeholders.

Task 6.0: Technical and Operational Support of Complimentary Project Proposal (CPP) (*Status: On Schedule)*

Apr 1, 2015:	First Submittal of CPP
May 1, 2015:	Upload data to IODP SSDB
Oct 1, 2015:	Revised Submittal of CPP
Jan 8, 2016:	Upload data to IODP SSDB
Jan 12-14, 2016:	SEP Review Meeting
Apr 1, 2016:	CPP Addendum Submittal
May 2, 2016:	Upload data to IODP SSDB
May 15, 2016:	Proponent Response Letter Submitted

Jun 21-23, 2016:	SEP Review Meeting
June 2016	Safety Review Report Submitted
July 2016	Safety Presentation PowerPoint
July 11 – 13, 2016	Environmental Protection and Safety Panel (EPSP) Meeting
Feb 2017	Submit Addendum V2
Feb 2017	Upload Revised Data
April 2017	EPSP Safety Review Report V2
May 2017	EPSP Safety Review Presentation V2
May 2017:	Scheduling of Hydrate Drilling Leg by IODP (JR Facility Board Meeting)
Spring 2019:	IODP Expedition

Table 4: Timing of Complimentary Project Proposal submission

Activity this period:

1. ***Presentation at EPSP (Environmental Protection and Safety Panel) Meeting***.
   IODP Proposal 887CPP2: Genesis of Methane Hydrate in Coarse-Grained Systems: Northern Gulf of Mexico Slope [GOM]2 was reviewed at the International Ocean Discovery Program (IODP) Environmental Protection and Safety Panel held at Texas A&M University, College Station, TX, July 11-13, 2016. The proposal was ranked as “excellent” by the Science Evaluation Panel in June, 2016 and forwarded on to the EPSP for a safety review of the proposed sites in preparation for final scheduling. Derek Sawyer presented the presentation.
   a. Contents of the Presentation:
      i. Part 1:
         1. Scientific goals of the proposed drilling expedition
         2. Drilling and sampling strategy
         3. Summary of potential safety issues and history of hydrate drilling by IODP
      ii. Part 2:
         1. Review of proposed sites in the Terrebonne Basin
         2. Review of proposed sites Orca Basin
         3. Review of proposed sites in the Mad Dog Basin
   b. Summary of Meeting Events
      i. Proposal 887CPP was reviewed during the final afternoon of the meeting (7/13/16). Attendees were required to sign a non-disclosure agreement in order to view seismic profiles included in the PowerPoint slides. The panel reviewed all of the PowerPoint slides and made recommendations for each site. The panel

provided guidance on (1) whether any of the 19 proposed sites (5 primary, 14 alternate) would have the potential to move forward in the drilling program or (2) whether there were clear issues that would require that a site's position be optimized or relocated because it would be highly unlikely that a proposed site could be approved in close proximity to the proposed location. However, because the seismic data could not be interactively reviewed in a live format it was decided to consider the meeting a "pre-review" and therefore no final recommendation would be made. We received no request or indication ahead of the meeting to bring live format data, and so, we did not have it available. It was determined that a full day review of this proposal would be scheduled for the next EPSP meeting in May 2017, and much of that time will be spent in an interactive format with the live seismic data.

c. Report of the Minutes
    i. Meeting minutes were received in July 2016. Primary results included:
    ii. A full day review for this proposal will be scheduled at the next EPSP meeting in May 2017. This will require a live data review of the seismic data in order to facilitate discussion on repositioning any sites, if necessary.
    iii. It was suggested to investigate the feasibility of reprocessing seismic data to increase resolution.
    iv. The panel was concerned with sites at Orca and Mad Dog that intersect faults and therefore it is recommended to the team to reposition these sites away from faults or to justify the need to intersect faults.

2. ***Strengthening of mapping efforts:***
    a. The feeling was this aspect of the program needed to be strengthened rapidly to accomplish this we did the following.
    b. UT Postdoctoral scientist working on mapping efforts left project, to fill that gap UT hired a mapping consultant. We are also recruiting for another Postdoctoral scientist and student worker.
    c. Decision to purchase seismic over GC 955 that illuminates the prospect considerably better

3. ***EPSP Facilities Board review***
    a. UT received a letter from Koppers (Chair of the Joides Resolution Facilities Board) and held discussions.
        i. UT must meet a revised schedule that culminates in an early May EPSP review
        ii. Re-processing of seismic data suggested
            1. UT needs to communicate with the EPSP regarding what data sets should be reprocessed but this a recommendation and not required.
        iii. Mad Dog could be presented but it is unlikely to be considered.
    b. Summary of planned schedule.

i. **Jan 19 – 20**: EPSP Workshop (UT Austin): Goal to review presentation and supporting documents for edits and feedback.
ii. **March 2 (*UT goal Feb*):** Submittal of Addendum (Add2) for Proposal 877-CPP2, provide updates on the relocated sites for the TBONE and ORCAB basins
iii. **March 10 (*UT goal Feb*):** Deadline to upload new data for relocated sites (SSDB)
iv. **March 10-April**: New data will be QA/QC-ed by the Science Support Office (SSO)
v. **April 6:** Submittal of Safety Review Report to the SSO for EPSP
vi. **May 2-3:** EPSP meeting in College Station, Texas (*UT requested move to ensure Flemings attendance*)
vii. **May 16-17:** JRFB meeting. Decision on scheduling of 877-CPP2

c. EPSP Walk Through Workshop Planned
   i. We will hold a workshop in Austin, TX on January 19 & 20, 2017 to review the geology and geophysics of well locations proposed for 1) the upcoming Marine Test (Sigsbee, GC 955) and 2) the envisioned IODP Expedition (IODP Proposal 887-CPP2) (Terrebone-WR 313, Orca, and Mad Dog).
   ii. The primary purpose of the workshop will be to do a 'dress-rehearsal' to prepare for the Environmental Protection and Safety Panel (EPSP) review. The goal for this review is to present the data and supporting documents as if it were the EPSP review and we will ask for feedback and edits. As time allows, we will also review the planned drilling at Sigsbee (GC-955) that is planned for Spring 2017.

Task 7.0: Continued Pressure Coring and Core Analysis System Modifications and Testing (*Status: On Schedule)*

Completed Tasks:

Subtask 7.1: Review and Complete NEPA Requirements (PCTB Land Test): Submitted and received approval for PCTB Land Test NEPA Requirements Y2Q1
Subtask 7.2: Pressure Coring Tool with Ball (PCTB) Land Test: *Y2Q1 report (Flemings, 2016a)*
Subtask 7.3: PCTB Land Test Report: GOM^2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST INITIAL REPORT in Y2 Q1 report (Flemings, 2016a)
Appendix A: GEOTEK CORING, HYBRID PRESSURE CORING TOOL WITH BALL VALVE (PCTB) 2015 LAND TEST PROGRAM in Y2 Q2 report (Flemings, 2016b)

Activity this period:

Subtask 7.4: PCTB Tool Modification, *Status: On Schedule*

The PCTB Tool Modification team finalized modifications to the PCTB and performed a Pre-Sea Trial Bench, Vertical, and Fit Tests.
Appendix A: Pettigrew Engineering PCTB Testing Report
Appendix B: Hybrid Pressure Coring Tool with Ball Valve Mark III (PCTB III), 2016 Pre-Sea Trial Tests

Pre-Sea Trial Bench Test

Objective: To determine the minimum force required to pull the Lower Inner Tube Plug into the Seal Sub. To eliminate hanging up of the plug seals on the sea sub entry surface causing an incomplete internal stroke resulting in loss of retained pressure and/or late boost.
Test: Assembled test apparatus such that the plug could be driven into the sea sub in a controlled manor while monitoring and recording the force required, no lubrication was used, the plug and seal sub were submerged in water
Result: Bench tests indicate both the double bevel and radiused seal reduce force to drive seals into the seal sub by 10%

Pre-Sea Trial Horizontal Space out Test

Objective: To fully vet all modified parts prior to the sea trial by latching in the fully assembled PCTB in an Outer Core Barrel Assembly (OCBA) and exercising the latching and unlatching function.
Test: Assembled a complete OCBA, laid out horizontally, and a completed PCTB with all modified parts installed.

Pre-Sea Trial Horizontal Space out Test

PCTB in cutting shoe configuration successfully latched and unlatched properly after two attempts in the bottom hole assembly (drill bit, bit sub, OCBA, landing sub, top sub, head sub). Spacing observed to be correct; latching confirmed by inability to move PCTB by bumping cutting shoe with sledgehammer. Some resistance in horizontal orientation due to friction between PCTB and BHA.

Pulling tool used with forklift to pull out PCTB; PCTB released and ball valve closed in correct sequence.

Figure 1.1: Pre-Sea Trial Horizontal Space out Test

Figure 1.2: Pre-Sea Trial Horizontal Space out Test

Pre-Sea Trial Vertical Full Function Pressure Test

Objective: To fully vet all modified parts, prior to the sea trial, by exercising the PCTB in a full function manor such that the PCTB is activated under pressure. Pressure recording devices will be use and analyzed to insure proper timing of the boost and retention of pressure is achieved.

Test: Assembled test apparatus similar to that of the previous horizontal full function pressure test except for orientating it in the vertical.

Procedure:

- Pressure increased in annulus to ~1000 psi
- PCTB actuated with pressure boost to 1500 psi
- Pressure and temperatures within autoclave and annulus monitored with data storage tags (DST) aka "fish pills"
- Annulus depressurized slowly to simulate rise of PCTB through borehole

Figure 1.3: Lower end of PCTB with ball valve capped and annulus filled with water and pressurized

Figure 1.4: PCTB actuated hydraulically from top to simulate pull on wireline

Task 8.0: Pressure Coring Tool with Ball (PCTB) Marine Field Test (*Status: On Schedule)*

Target Marine Test Dates: March – May 2017

Completed Tasks

Decision Point 2: Marine Field Test Stage Gate: Submitted necessary documents to meet requirements of stage gate. This authorization was granted based on documentation received to support the Marine Field Test to be conducted under Task 8.4.

Activity this period:

Subtask 8.1: Review and Complete NEPA Requirements (*Status: On Schedule)*
Continued process of collecting and reviewing information for DOE Environmental Questionnaire.

Subtask 8.2: Marine Field Test Detailed Drilling/Logging/Coring/Sampling Operational Plan *(Status: On schedule)*

1. Held Marine Test planning workshop on 9/7/2016 with Helix and subcontractors. Discussed project objectives, geologic prognosis, global hydrate projects and 2009 Hydrate JIP offset review, high level drilling & coring plans, mud and cement program requirements, wireline logging proposal, deck layout requirements, mobilization & demobilization requirements, high-level logistics plans, & permit requirements. Workshop format provided opportunity for identification & discussion of concerns & issues. Also identified were actions and issues that needed resolution prior to permit application. An action list of outstanding planning activities with assigned accountabilities was developed for resolution by mid-October. Planning progress was documented in an Action Tracker and continues to be updated weekly.
2. Received first drafts of mud program, deck layout, and P&A program.
3. Evaluations are underway for wireline access through the top drive, BHA protection during cementing, cold shuck hang-off, use of a lockable float valve, and wellbore re-entry options.
4. Completed review of historical use of drilling mud with the PCTB system.
5. Identified minimum training requirements for UT Group.

Subtask 8.3: Marine Field Test Documentation and Permitting (*Status: On schedule)*

1. Continued preparation of BOEM-0327 'Application for Permit to Conduct Scientific Research on the OCS'.
2. Continued review of requirements for BSEE – 0123 "Application for Permit to Drill".
3. Developed structure for operational plan documentation.
   a) High-level overview of the Marine Test execution plan will be documented in a 'Project Execution Plan (PEP)'. Within the PEP, in addition to high-level summaries, there will be references to a number of stand-alone detailed planning documents.
   b) Stand-alone detailed planning documents to include: communication plan, science plan, well program, permitting applications, contracting strategy, mobilization plan, demobilization

plan, core transport plan, risk assessment & management documentation, logistics plan, contingency plans, management of change, decision-making chart, and roles & responsibilities. A number of the stand-alone planning documents are in progress with individual leads assigned.

4. Established Marine Test document naming and numbering conventions.

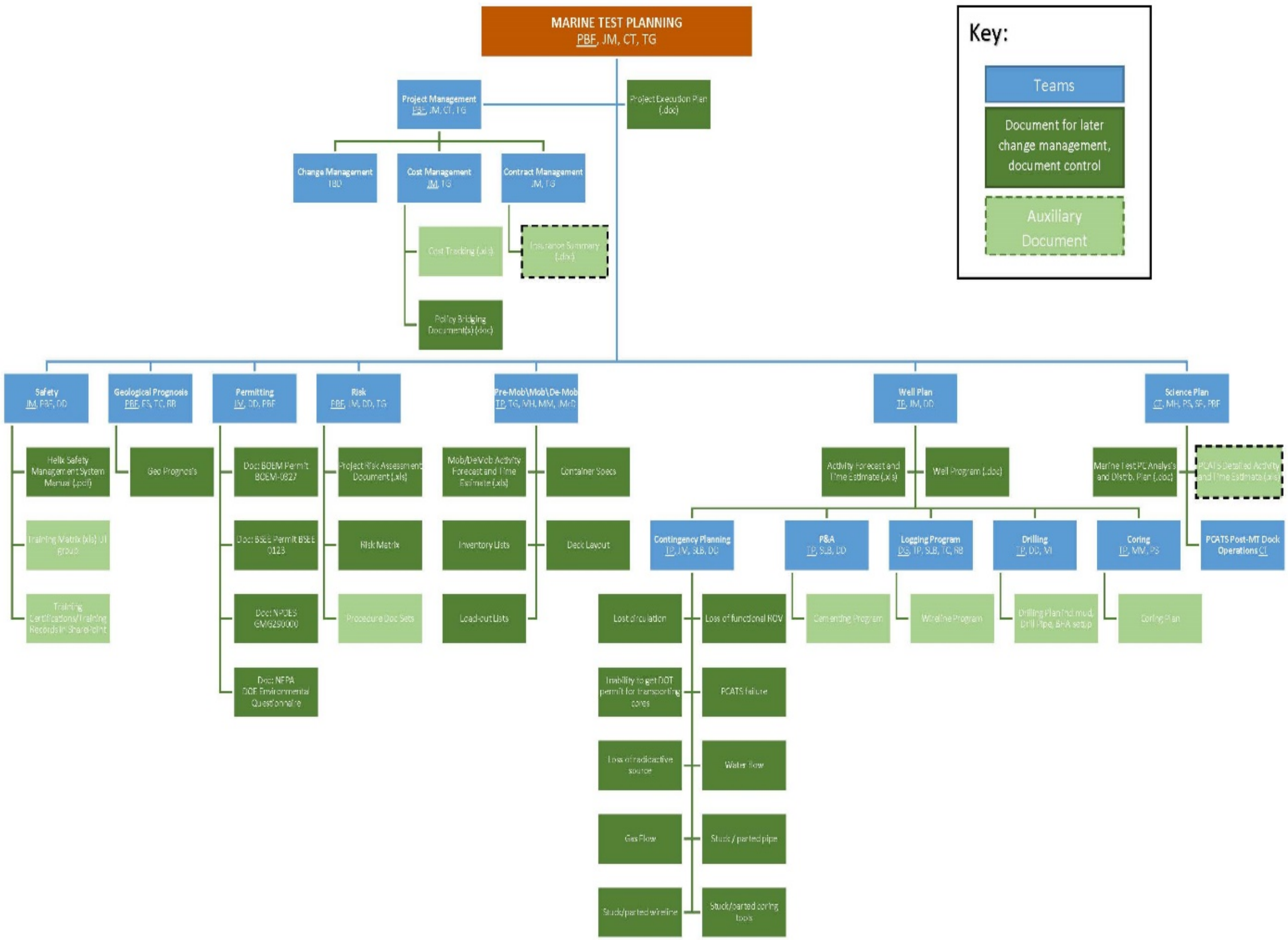


Figure 1.5: Marine Test Planning Team Structure and Documents

Subtask 8.4: Marine Field Test of Pressure Coring System (*Status: On schedule)*

1. Continued contract negotiations with Helix. Hired outside counsel with maritime law expertise to assist with liability terms.
2. Continued risk evaluation and determination of insurance requirements by UT Office of Risk Management and insurance brokers.
3. Signed letter of agreement with Helix to allow project planning while continuing to negotiate contract. Letter commits UT to a project-management Minimum Charge, payable only if ultimately no contract is executed. Helix Project Team initiated.
4. Project added to Helix Q-4000 rig schedule. Currently on the Q-4000 rig schedule after completion of an ABS inspection in Brownsville, Texas.

Subtask 8.5: Marine Field Test Report (*Status: Future Task)*
Nothing to report this period.

Task 9.0: Pressure Core Transport, Storage, and Manipulation (*Status: On Schedule)*

Completed Tasks:

Subtask 9.1: Review and Complete NEPA Requirements (Core Storage and Manipulation):
Submitted and received approval for NEPA Requirements Y2Q2.

Activity this period:

Subtask 9.2: Hydrate Core Transport (*Status: On schedule)*
Contract with Geotek is still in place for the transport of pressure cores over land. The remaining challenge is for Geotek to secure approval for the use of their Overpacks with the DOT.

Subtask 9.3: Storage of Hydrate Pressure Cores (*Status: Future Task)*
Nothing to report this period

Subtask 9.4: Refrigerated Container for Storage of Hydrate Pressure Cores (*Status: On Schedule)*
A bid for the construction of the container by Harris Environmental was accepted and the contract is now in place. Harris has built the container and is in the processes of delivering it. SpawGlass has finished refurbishing the space inside the Jackson School building to receive the container. The walk-in container will be capable of storing, moving, and monitoring the pressure cores. Storage capability includes the ability to maintain conditions necessary to keep twenty 1.2 m pressure cores for the duration of the project.

Subtask 9.5 – 9.7: Hydrate Core Manipulator and Cutter Tool, Hydrate Core Effective Stress Chamber, Hydrate Core Depressurization Chamber (*Status: On Schedule)*
Parts have been ordered for the Pressure Core Manipulator and Cutting Tool, Hydrate Core Effective Stress Chamber, and Depressurization Chamber.

1. Pressure Core Manipulator and Cutting Tool
    a. A smaller version (length-wise) of the Geotek PCATS.
2. Hydrate Core Effective Stress Chamber
    a. Chamber will couple with the Manipulator and Cutting Tool to receive samples.
    b. The chamber will be capable of measuring effective stress, permeability, and extracting liquids for pore fluid analysis.
3. Depressurization Chamber
    a. The chamber includes a high pressure gas manifold and gas sampling equipment

Task 10.0 Pressure Core Analysis (*Status: On Schedule)*

Continued planning for acquisition of pressure cores. Two documents one outlining the Pressure Core Analysis to be done on-board the Marine Test Rig (Marine Test Science On-Board Plan) and the other outlining the details of the Pressure and Routine Core analysis to be done on-shore (Marine Test Science On-Shore Plan) are being developed and will be released. We still envision the establishment of a technical advisory council to provide guidance on the analysis and distribution of routine and pressure cores. We will ask the council to review these documents.

Subtask 10.1: Routine Core Analysis (*Status: Future Task)*
Nothing to report this period.

Subtask 10.2: Pressure Core Analysis (*Status: Future Task)*
The quality and amount of analysis that can be done on-board is highly dependent on the Marine Test Drilling and Coring timeline. Details of the dependency including the expected number of cores, prioritization of core experiments, and process for assigning cores to specific assignments can be found in the on-board document.

Subtask 10.3: Hydrate Core-Log-Seismic Synthesis (*Status: Future Task)*
Nothing to report this period.

Task 11.0: Update Pre-Expedition Drilling / Logging / Coring / Sampling Operational Plan (Field Program / Research Expedition) (*Status: On Schedule)*

Nothing to report this period.

Task 12.0: Field Program / Research Expedition Vessel Access (*Status: Future Task)*

Nothing to report this period.

Decision Point 3: Budget Period Continuation

Nothing to report this period.

<u>FUTURE – BUDGET PERIOD 3A, & 3B: Not Started</u>

C. What do you plan to do during the next reporting period to accomplish the goals?

Task 1.0: Project Management and Planning (continued from prior phase)

Will continue to execute the project in accordance with the approved PMP, manage and control project activities in accordance with their established processes and procedures to ensure subtasks and tasks are completed within schedule and budget constraints defined by the PMP. A key goal of the next quarter is to finalize contracts for the Marine Test.

Task 6.0: Technical and Operational Support of Complimentary Project Proposal (CPP)

During the next reporting period we will focus on both the geological analysis of our CPP drilling locations and the safety analysis of these locations in preparation for the February submissions to the EPSP and SEP (see section B). The analysis will be used to either modify proposed drilling locations for safety or science purposes or strengthen the justification for drilling in the locations currently proposed.

Task 7.0: Continued Pressure Coring and Core Analysis System Modifications and Testing

In the next reporting period we will finalize manufacturing for tool modifications in preparation for Marine Field Test.

Task 8.0: Pressure Coring Tool with Ball (PCTB) Marine Field Test

Continue to refine drilling plan in preparation for marine test, finalize contracts, and begin permitting.

Task 9.0: Pressure Core Transport, Storage, and Manipulation

Secure DOT approval of Pressure Core Transport over land in Overpacks through Geotek. Geotek anticipates that this approval will come in the next couple of weeks. Continue with the build and installation of equipment and storage container at UT Austin. The installation of the container will happen in sections starting with the floor. Geotek will assemble the Pressure Core tools in the UK.

Task 10.0 Pressure Core Analysis

Continue planning for acquisition and analysis of pressure cores for the PCTB Marine Field Test using the On-Board and On-Shore Science Plan Documents. Continue comparing various options for the allocation of PCATS time for their corresponding impact on core distribution and science. Identify the required man-power on-board the Marine Test and identify persons for each roll as required (the

Science team). Establish a Marine Test Science Technical Advisory Board and work with them to review the Science plan and announce the method for requesting Marine Test samples to the Hydrate community.

Task 11.0: Update Pre-Expedition Drilling / Logging / Coring / Sampling Operational Plan (Field Program / Research Expedition) (*Status: On Schedule)*

No work planned for the next reporting period.

Task 12.0: Field Program / Research Expedition Vessel Access (*Status: Future Task)*

No work planned for the next reporting period.

2. PRODUCTS:

A. Publications, conference papers, and presentations

Cook, A.E., & Sawyer, D., 2015, Methane migration in the Terrebonne Basin gas hydrate system, Gulf of Mexico, presented at 2015, Fall Meeting, AGU, San Francisco, CA, 14-18 Dec.

Cook, A.E., & Sawyer, D., 2015, The mud-sand crossover on marine seismic data: Geophysics, v. 80, no. 6, p. A109-A114, 10.1190/geo2015-0291.1.

Cook, A.E., and Waite, 2016, Archie's saturation exponent for natural gas hydrate in coarse-grained reservoir, presented at 2016 Gordon Research Conference from Feb28 to Mar04 in Galveston, TX, United States.

Cook, A.E., Hillman, J., & Sawyer, D., 2015, Gas migration in the Terrebonne Basin gas hydrate system, Abstract OS23D-05 presented at 2015, Fall Meeting, AGU, San Francisco, CA, 14-18 Dec.

Fortin, W., Goldberg, D.S., Holbrook, W.S., and Küçük,H.M., 2016, Velocity analysis of gas hydrate systems using prestack waveform inversion, Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX, Feb 28 - March 4, 2016.

Fortin, W., Goldberg, D.S., Küçük, H.M, 2016, Methane Hydrate Concentrations at GC955 and WR313 Drilling Sites in the Gulf of Mexico Determined from Seismic Prestack Waveform Inversion, EOS Trans. AGU, Fall Meeting, Session 13837: Experiments, Modeling and Field Studies on Gas Hydrate Formation, San Francisco, CA Dec 12---16, 2016.

Goldberg, D., H.M. Küçük, S. Haines, G. Guerin, 2016. Reprocessing of high resolution multichannel seismic data in the Gulf of Mexico: implications for BSR character in the Walker Ridge and Green Canyon areas, Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX, Feb 28 - March 4, 2016.

Hillman, J., Cook, A. & Sawyer, D., 2016, Mapping and characterizing bottom-simulating reflectors in 2D and 3D seismic data to investigate connections to lithology and frequency dependence, presented at 2016 Gordon Research Conference from Feb28 to Mar04 in Galveston, TX, United States.

Hillman, J, Cook, A.E., Sawyer, D., Küçük, H.M., and Goldberg, D.S., 2016. The character and amplitude of bottom-simulating reflectors in marine seismic data, Earth & Plan Sci Lett., in review.

Küçük, H.M., Goldberg, D.S, Haines, S., Dondurur, D., Guerin, G., and Çifçi, G., 2016. Acoustic investigation of shallow gas and gas hydrates: comparison between the Black Sea and Gulf of Mexico, Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX, Feb 28 - March 4, 2016.

Majumdar, U., Cook, A. E., Shedd, W., and Frye, M., 2016, The connection between natural gas hydrate and bottom-simulating reflectors: Geophysical Research Letters, DOI: 10.1002/2016GL069443

Malinverno, A., 2015. Monte Carlo inversion applied to reaction-transport modeling of methane hydrate in continental margin sediments, Fall AGU Meeting, San Francisco, Calif., Abstract OS23B-2003.

Malinverno, A., 2016. Modeling gas hydrate formation from microbial methane in the Terrebonne basin, Walker Ridge, Gulf of Mexico, Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX, Feb 28 - March 4, 2016.

Meazell, K., & Flemings, P.B., 2016, New insights into hydrate-bearing clastic sediments in the Terrebonne basin, northern Gulf of Mexico. Gordon Research Conference on Natural Gas Hydrate Systems.

Meazell, K., & Flemings, P.B., 2016, The depositional evolution of the Terrebonne basin, northern Gulf of Mexico. 5th Annual Jackson School Research Symposium.

Meazell, K., 2015, Methane hydrate-bearing sediments in the Terrebonne basin, northern Gulf of Mexico, Abstract OS23B-2012 presented at 2015 Fall Meeting, AGU, San Francisco, CA. 14-18 Dec.

Phillips, S.C., Borgfedlt, T., You, K., Meyer, D., and Flemings, P., 2016, Dissociation of laboratory-synthesized methane hydrate by depressurization. Poster presented at 2016 Gordon Research Conference and Gordon Research Seminar on Natural Gas Hydrates. Poster presented at 2016 Gordon Research Conference from Feb28 to Mar04 in Galveston, TX, United States.

Treiber, K, Sawyer, D., & Cook, A., 2016, Geophysical interpretation of gas hydrates in Green Canyon Block 955, northern Gulf of Mexico, USA. Poster presented, poster presented at 2016 Gordon Research Conference from Feb28 to Mar04 in Galveston, TX, United States.

Worman, S. and, Flemings, P.B., 2016, Genesis of Methane Hydrate in Coarse-Grained Systems: Northern Gulf of Mexico Slope (GOM^2). Poster presented at UT GeoFluids Consortia Meeting from March 2nd- March 4th in Austin, TX, United States.

Yang, C., Cook, A., & Sawyer, D., 2016, Geophysical interpretation of the gas hydrate reservoir system at the Perdido Site, northern Gulf of Mexico, presented at 2016 Gordon Research Conference from Feb28 to Mar04 in Galveston, TX, United States

You, K.Y., DiCarlo, D. & Flemings, P.B., 2015, Quantifying methane hydrate formation in gas-rich environments using the method of characteristics. Abstract OS23B-2005 presented at 2015, Fall Meeting, AGU, San Francisco, CA, 14-18 Dec.

You, K.Y., Flemings, P.B., & DiCarlo, D., 2015, Quantifying methane hydrate formation in gas-rich environments using the method of characteristics. Poster presented at 2016 Gordon Research Conference and Gordon Research Seminar on Natural Gas Hydrates. Poster presented at 2016 Gordon Research Conference from Feb28 to Mar04 in Galveston, TX, United States.

B. Website(s) or other Internet site(s)

Project Website: http://www.ig.utexas.edu/gom2/

Project SharePoint: https://sps.austin.utexas.edu/sites/GEOMech/doehd/teams/

C. Technologies or techniques

Nothing to Report.

D. Inventions, patent applications, and/or licenses

Nothing to Report.

E. Other products

Flemings, P. B., 2014, Y1Q1 Quarterly Research Performance Progress Report (Period ending 12/31/2014), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2015, Y1Q2 Quarterly Research Performance Progress Report (Period ending 3/31/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2015, Y1Q3 Quarterly Research Performance Progress Report (Period ending 6/30/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2015, Y1Q4 Quarterly Research Performance Progress Report (Period ending 9/30/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2015, Phase 1 Report (Period ending 9/30/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2016, Y2Q1 Quarterly Research Performance Progress Report (Period ending 12/31/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2016, Y2Q2 Quarterly Research Performance Progress Report (Period ending 3/31/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2016, Y2Q3 Quarterly Research Performance Progress Report (Period ending 6/30/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

3. CHANGES/PROBLEMS:

A. Changes in approach and reasons for change

1. Hired a consultant to assist with prospect maturation.

B. Actual or anticipated problems or delays and actions or plans to resolve them

1. Well completions (plug and abandon) requirements are significantly more involved than originally envisioned because the regulations have changed. This affects total rig time and contractor fees.
2. Development of scientific plan has led to the conclusion that it will be extremely challenging to process all the core and appropriately analyze it while on the drilling platform. One alternative being considered is whether to extend the analysis to include a dock side phase.

C. Changes that have a significant impact on expenditures

1. Man-hours needed for Marine Test have exceeded original projections due to lengthy negotiations with UT and more complex planning than envisioned. At this point these costs are covered under the current budget, but may require additional funds.
2. Insurance and bonding costs for the Marine Test are still being resolved. Current projections exceed original budget numbers.

D. Change of primary performance site location from that originally proposed

Nothing to Report.

4. SPECIAL REPORTING REQUIREMENTS:

A. CURRENT - BP2 / Phase 2

Task 1 – Revised Project Management Plan (Complete)

Subtask 7.03 – PCTB Land Test Report (Complete)

Subtask 8.05 – Pressure Core Marine Field Test Report

Task 11 – Refined Field Program Operational Plan Report

B. <u>FUTURE - BP 3 / Phase 3</u>

Phase 3A

A Phase 3A Report encompassing the refined Operational Plan, pressure coring team report, and permitting report

Task 14 - Field Program Operational Plan report

Task 15 – Field Program Hazards Report

Phase 3B

Task 16 – IODP Preliminary Expedition Report

Task 18 – Project Sample and Data Distribution Plan

Task 18 – IODP Proceedings Expedition Volume

Task 18 – Expedition Scientific Results Volume

5. BUDGETARY INFORMATION:

Budget Period 2 cost summary is outlined below.

Baseline Reporting Quarter	Budget Period 2							
	Y1Q1		Y1Q2		Y1Q3		Y1Q4	
	10/01/15-12/31/15		01/01/16-03/31/16		04/01/16-06/30/16		07/01/16-09/30/16	
	Y1Q1	Cumulative Total	Y1Q2	Cumulative Total	Y1Q3	Cumulative Total	Y1Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 1,805,358	$ 1,805,358	$ 1,327,931	$ 3,133,289	$ 492,932	$ 3,626,221	$ 492,932	$ 4,119,153
Non-Federal Share	$ 471,771	$ 471,771	$ 471,771	$ 943,542	$ 471,771	$ 1,415,313	$ 471,771	$ 1,887,084
Total Planned	$ 2,277,129	$ 2,277,129	$ 1,799,702	$ 4,076,831	$ 964,703	$ 5,041,534	$ 964,703	$ 6,006,237
Actual Incurred Cost								
Federal Share	$ 788,040	$ 788,040	$ 802,088	$ 1,590,128	$ 862,023	$ 2,452,151	$ 920,499	$ 3,372,650
Non-Federal Share	$ 267,114	$ 267,114	$ 258,648	$ 525,762	$ 308,579	$ 834,341	$ 246,863	$ 1,081,204
Total Incurred Cost	$ 1,055,154	$ 1,055,154	$ 1,060,736	$ 2,115,890	$ 1,170,602	$ 3,286,492	$ 1,167,362	$ 4,453,854
Variance								
Federal Share	$ (1,017,318)	$ (1,017,318)	$ (525,843)	$ (1,543,161)	$ 369,091	$ (1,174,070)	$ 427,567	$ (746,503)
Non-Federal Share	$ (204,657)	$ (204,657)	$ (213,123)	$ (417,780)	$ (163,192)	$ (580,972)	$ (224,908)	$ (805,880)
Total Variance	$ (1,221,975)	$ (1,221,975)	$ (738,966)	$ (1,960,941)	$ 205,899	$ (1,755,042)	$ 202,659	$ (1,552,383)

Baseline Reporting Quarter	Budget Period 2							
	Y2Q1		Y2Q2		Y2Q3		Y2Q4	
	10/01/16-12/31/16		01/01/17-03/31/17		04/01/17-06/30/17		07/01/17-09/30/17	
	Y2Q1	Cumulative Total	Y2Q2	Cumulative Total	Y2Q3	Cumulative Total	Y2Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 1,096,922	$ 5,216,075	$ 10,209,921	$ 15,425,996	$ 1,001,922	$ 16,427,918	$ 1,001,922	$ 17,429,840
Non-Federal Share	$ 848,570	$ 2,735,654	$ 848,569	$ 3,584,223	$ 848,569	$ 4,432,792	$ 848,569	$ 5,281,361
Total Planned	$ 1,945,492	$ 7,951,729	$ 11,058,490	$ 19,010,219	$ 1,850,491	$ 20,860,710	$ 1,850,491	$ 22,711,201
Actual Incurred Cost								
Federal Share								
Non-Federal Share								
Total Incurred Cost								
Variance								
Federal Share								
Non-Federal Share								
Total Variance								

Table 5

6. REFERENCES

Flemings, P. B., 2016a, Y2Q1 Quarterly Research Performance Progress Report (Period ending 12/31/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2016b, Y2Q2 Quarterly Research Performance Progress Report (Period ending 3/31/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

7. ACRONYMS

CPP	Complimentary Project Proposal
DOE	Department of Energy
EPSP	Environmental Protection and Safety Panel
gpm	Gallons per minute
ICL	Instrumented Core Liner
ID	Inner diameter
IODP	International Ocean Discovery Program
LDEO	Lamont–Doherty Earth Observatory
LWD	Logging While Drilling
m	meter
MADOG	Mad Dog
NEPA	National Environmental Policy Act
OCB	Outer Core Barrel
OCBA	Outer Core Barrel Assembly
OSU	Ohio State University
PCATS	Pressure Core Analysis and Transfer System
PCTB	Pressure Coring Tool with Ball Valve
PRL	Proponent Response Letter
SEP	Science Evaluation Panel
SSDB	Site Survey Data Bank
TBONE	Terrebonne
TFA	Total Flow Area
UNH	University of New Hampshire
UT	The University of Texas

Pettigrew Engineering PCTB Testing Report

18 July 2016 through 22 July 2016
Geotek Facility in West Valley City, Utah

Summary

Following land testing of the PCTB the decision was made to make some minor modifications to a) reduce or eliminate the potential for autoclave upper seal hang up and thus a delayed boost, b) reduce or eliminate core liner and core tube collapse, and c) reduce or eliminate migration of debris laden fluid from flowing inside the PCTB. A series of tests were performed to verify the function of the new and modified parts prior to the sea trial. The tests were performed at the Geotek facility in West Valley City, Utah from 18 July 2016 through 22 July 2016. The tests consisted of, a) bench testing various configurations of seal sub seal entry configurations and associated autoclave plug seal configurations, b) vertical full function pressure tests, and c) a full assembly space out with the outer core barrel sub assembly.

Over all the PCTB functioned quite well during the tests. Some minor problems occurred that where identified and fixed such that they should not occur again. All new and modified parts functioned as designed and are now considered part of the "standard" PCTB assembly.

Monday 18 July 2016

The day started with an overview presentation by Geotek of the modifications made to the PCTB and of the proposed testing procedures.

Bench Test of Various Seal Sub and Seal Configurations

Geotek also reviewed the results of the bench testing of the various seal sub and seal configurations which had been previously completed. The seal sub configurations included the current steep angle bevel seal entry, a double bevel seal entry resulting in a low angle seal contact surface, and a large radius seal entry. The seal configurations included the existing Poly-Pak and o-ring combination and a double Poly-Pak combination. The test results indicate that both the seal sub double bevel and large radius seal entry configurations, in conjunction with the double Poly-Pak seal configuration, produced a 10% reduction in the force required to drive the seals into the seal sub, as compared to the existing seal sub with a steep angle seal entry and a Poly-Pak and o-ring seal configuration.

Based on the bench test results, the vertical full function test procedure was amended to include only the double bevel seal entry and the large radius seal entry seal sub configurations in conjunction with only the double Poly-Pak seal configuration.

Vertical Full Function Testing

The Geotek proposed testing procedures called for starting with the current steep angle seal sub and Poly-Pak and o-ring seal combination. Since the current configured PCTB was deployed extensively during the land test and during horizontal full function bench testing prior to the land test, the decision was made not to repeat these tests and go directly to the modified configurations for testing.

Note, except for the full assembly space out test description, the term PCTB refers to only the autoclave, pressure section, and upper end subassembly.

Vertical Full Function Test #1

The PCTB was configured with all the modified parts including the double bevel seal sub and double Poly-Pak seals.
Boost pressure was set at ~1,500 psi.

1350: The PCTB was picked up vertically.
The annulus was pressurized and a leak occurred at one of the pressure hose connections and the PCTB was lowered and the connection tightened.

1410: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated, stroking the PCTB internally.
The annulus pressure remained at ~1,000 psi.
The autoclave pressure increased to ~1,550 psi, indicating the boost had fired and the ball valve had closed trapping the boost pressure.
The annulus pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure remained at ~1,550 psi, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed.

GOOD TEST!

<u>Vertical Full Function Test #2</u>

The PCTB was configured with all the modified parts including the double bevel seal sub and double Poly-Pak seals.
Boost pressure was set at ~1,500 psi.

1700: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated stroking the PCTB internally.
The annulus pressure remained at ~1,000 psi.
The autoclave pressure increased to ~1,550 psi, indicating the boost had fired and the ball valve had closed trapping the boost pressure.
The annular pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure remained at ~1,550 psi, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed.

GOOD TEST!

Tuesday 19 July 2016

<u>Vertical Full Function Test #3</u>

The PCTB was configured with all the modified parts including the double bevel seal sub and double Poly-Pak seals.
The boost pressure was set at ~1,500 psi.

1115: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated stroking the PCTB internally and it only partially stroked.
Note: A small hydraulic ram is used to stroke the tool.

The actuator was raised and lowered several times when the PCTB finally completed a full stroke.
The annulus pressure remained at ~1,000 psi.
The autoclave pressure increased to ~1,550 psi, indicating the boost had fired and the ball valve had closed, trapping the boost pressure.
The annular pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure remained at ~1,550 psi, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed.

GOOD TEST!

Discussion:

Since the boost pressure was captured, the cause of this particular hang up was not the autoclave upper seal hanging up on the seal sub.

The maximum force applied by the actuator to the release rod was ~2,000 lbs. This force is well within the capabilities of a wireline unit in the field. Since the modified parts now prevent the PCTB from releasing from the BHA until it is fully stroked internally, should this particular hang up occurred in the field, the wireline operator would be able to work the wireline up and down and achieve the same results. In the event the PCTB fails to stroke in the field, it will be necessary to shear release the pulling tool and pull it out of the hole. Then the emergency pulling tool, which engages only the PCTB upper latch, will have to be run in the hole to recover the PCTB.

Upon disassembly, no definitive evidence was observed as to the cause of the hang up. However, one of the port covers was found to be slightly above flush with the OD of the tool and may have been the cause of the hang up.

Although this incident by itself is not considered to be of concern, any further hang ups will be noted and evaluated collectively.

<u>Vertical Full Function Test #4</u>

The PCTB was configured with all the modified parts including the double bevel seal sub and double Poly-Pak seals.
The boost pressure was set at ~1,500 psi.

1400: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated stroking the PCTB internally without incident.
The annulus pressure remained at ~1,000 psi.
The autoclave pressure increased to ~1,550 psi, indicating the boost had fired and the ball valve had closed trapping the boost pressure.
The annular pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure remained at ~1,550 psi, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed.

GOOD TEST!

<u>Vertical Full Function Test #5</u>

The PCTB was configured as before except for installing the large radiused seal sub
The boost pressure was set at ~1,500 psi.

1400: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated stroking the PCTB internally without incident.
The annulus pressure remained at ~1,000 psi.
The autoclave pressure increased to ~1,550 psi, indicating the boost had fired and the ball valve had closed trapping the boost pressure.
The annular pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure remained at ~1,550 psi, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed.

GOOD TEST!

Wednesday 20 July 2016

Vertical Full Function Test #6

The PCTB was configured with all the modified parts including the large radiused seal sub and double Poly-Pak seals.
The boost pressure was set at ~1,500 psi.

1130: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated and the PCTB stroked only ~1/2".
The actuator was worked up and down several times without any further advancement in the stroke.
All pressure was bled off and the PCTB was rigged down for autopsy.

Discussion:

Upon disassembly, one of the detents under the collet release sleeve was found not to have retracted into its groove, thus jamming the collet release sleeve which in turn jammed on the seal sub ID.
Note, due to the short actuator stroke, the tool is partially stroked when it is picked up for the vertical full function test. The pre-set partial stroke positions the collet release sleeve immediately below the seal sub ID upset, resulting in the very short partial stroke before hang up.

An o-ring is used as a spring to force the detents into their groove. This o-ring is typically not changed between deployments and may have stretched somewhat, thus supplying less spring force to pull the detents into the groove. Also, a slight burr was observed on some of the detent edges. All of the edges on all of the detents were filed down to eliminate any remaining burrs that might have attributed to the hang up and the o-ring spring was changed out.

The PCTB was reassembled with a new detent o-ring spring and filed detents.
The boost pressure was set at ~1,500 psi.

1400: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated stroking the PCTB internally without incident.
The annulus pressure remained at ~1,000 psi.
The autoclave pressure increased to ~1,530 psi, indicating the boost had fired and the ball valve had closed trapping the boost pressure.

The annular pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure remained at ~1,530 psi, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed.

GOOD TEST!

Vertical Full Function Test #7

The PCTB was configured with the large radiused seal sub and double Poly-Pak seals.
The boost pressure was set at ~1,500 psi.

1600: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated and the PCTB only partially stroked.
The actuator was worked up and down several times when both the annulus pressure and the autoclave pressure were observed to increase to ~1,125 psi and the PCTB could not be stroked further.
The annular pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure dropped from ~1,125 to ~1,070 psi and then remained there, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed, trapping the partially boosted annular pressure.
The PCTB was rigged down for autopsy.

Discussion:

From visual observation of the pressure gauges and readouts, it appears the boost occurred before the autoclave was fully sealed, as indicated by both the annulus and the autoclave pressures increasing simultaneously while stroking the PCTB. Upon disassembly, the boost reservoir pressure was found to be below what is normally observed.

After reviewing the recorded fish pill pressure data plots of the annulus and autoclave pressures, it is apparent that the ball valve delayed closing. The boost fired as designed and since the ball valve was not sealed both the annulus and the autoclave pressures increased ~125 psi. Since the annular volume is connected to an accumulator during the test, the accumulator absorbed some of the boost pressure. Thus, only 125 psi was added to the system rather than the full 500 psi of the boost. This is indicated by a 1,175 psi spike in the autoclave pressure data before the system equalized at ~1,100 psi.

As the annulus pressure was slowly bled off, both the annulus pressure and autoclave pressure dropped together until the pressure reached ~1,025 psi at which point the autoclave pressure stopped dropping. This is when the ball valve finally closed, trapping the partially boosted annulus pressure.

Autopsy Results:

Upon disassembly of the ball valve, it was found to be closed in the normal position. The reset tool was installed to compress the ball valve spring for further disassembly. When the reset tool was removed, the seal carrier hung up inside the ball valve housing. A slight tap on the housing with a hammer freed the seal carrier and it slammed home driven by the compressed ball valve spring. The reset tool was installed again to compress the ball valve spring and again when the reset tool was removed the seal carrier hung up inside the ball valve housing.

Small dings were observed at the top of the ball valve housing windows on the ID. These are caused by the ball moving too far upward when the reset tool engaged and tightened too much. These dings may have contributed to a bureau drawer sticking problem.

Further Discussion:

As a rule of thumb, if the length of the throat of the seal housing divided by its diameter is equal to or near the coefficient of friction then a "bureau drawer effect" can occur. In this case that is 0.825 / 3.062 = 0.27 which is very close to the coefficient of friction for stainless steel. This appears to be a case of classic bureau drawer sticking. The suggestion was made to eliminate all dings and to look at reducing the coefficient of friction by coating the ID of the ball valve housing or the OD of the seal carrier, or both, with a low friction coating. Another possibility suggested is to add more centralization for the seal carrier as it moves through the housing seal bore.

Thursday 21 July 2016

The day began with the disassembly of the ball valve from the previous days test, looking for the cause of delayed ball valve closure. Refer to "Autopsy Results" and "Further Discussion" topics above.

<u>Vertical Full Function Test #8</u>

The PCTB was configured with the large radiused seal sub and double Poly-Pak seals.
The boost pressure was set at ~1,500 psi.

1210: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated stroking the PCTB internally without incident.
The annulus pressure remained at ~1,000 psi.
The autoclave pressure increased to ~1,545 psi, indicating the boost had fired and the ball valve had closed trapping the boost pressure.
The annular pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure climbed to ~1,560 psi, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed.

GOOD TEST!

<u>Vertical Full Function Test #9</u>

The PCTB was configured with the large radiused seal sub and double Poly-Pak seals.
The boost pressure was set at ~1,500 psi.

1345: The PCTB was picked up vertically.
The annulus was pressurized to ~1,000 psi.
The autoclave pressure increased to ~1,000 psi, indicating the ball valve was open.
The actuator was actuated stroking the PCTB internally without incident.
The annulus pressure remained at ~1,000 psi.
The autoclave pressure increased to ~1,535 psi, indicating the boost had fired and the ball valve had closed trapping the boost pressure.
The annular pressure was slowly bled off to zero, simulating coming out of the hole on wireline.
The autoclave pressure climbed to ~1,545 psi, indicating the ball valve was closed and sealed and the autoclave upper seal was engaged and sealed.

GOOD TEST!

End vertical full function testing.

Friday 22 July 2016

<u>Full Assembly Space Out Test</u>

1000: Begin assembling outer core barrel (OCB) components horizontally.
The PCTB lower section was slid part way into the OCB using a fork lift. A lifting clamp was attached to the top of the lower section to keep it from sliding further, similar to how it is done in the field except for the PCTB being horizontal. The PCTB upper section was picked up and made up to the lower section. The lifting clamp was removed and the full PCTB assembly was slid into the OCB. Note, the running tool was not used since it would go too far inside the OCB to be released manually. Thus a piece of 4x4 lumber was used to drive the PCTB assembly into the OCB.

The PCTB stopped sliding about 12” above the landing point when the outer latch dogs contacted the head sub ID. Note, normally the outer latch dogs are retracted by the weight of the PCTB hanging on the running tool. The PCTB was pulled out of the OCB until the outer latch dogs were accessible. The running tool was installed in the PCTB to retract the outer latch dogs. A spare latch sleeve was slid over the outer latch dogs to keep them retracted. The running tool was manually released and removed. The PCTB was then slid back into the OCB as far as it would go while removing the spare latch sleeve once the outer latch dogs had entered the head sub ID.

It appeared that the PCTB was within 1/4" - 1/2" of latching but had not latched. To confirm that the PCTB was not latched, a sledge hammer was used to bump the PCTB out of the OCB by hammering on the cutting shoe. The PCTB continued to slide out of the OCB confirming that it was not latched.

The assemblies were double checked and found to be OK. The head sub was removed from the OCB to verify that the latch sleeve had not come lose and backed off. Note, removing the head sub allowed the outer latch dogs to expand inside the OCB and they cannot be retracted without engaging the pulling tool. The latch sleeve was found to be tight and the length verified to be correct. The head sub was made up to the OCB again and shouldered against the top sub. Since the outer latch dogs were locked in the expanded configuration and could not pass through the latch sleeve ID when the head sub was made up, the PCTB had to be latched in place. To verify the PCTB was latched into the OCB the cutting shoe was once again bumped with a sledge hammer and the PCTB would not move, indicating the PCTB was latched into the OCB.

The overall space out was checked and found to be correct. Thus, when the PCTB is made up with the new modified parts it will latch into the normal/standard PCTB BHA in the field.

The pulling tool was then inserted into the PCTB. A strap was connected between the pulling tool and the fork lift. The fork lift was used to pull the PCTB out of the OCB. Closing of the ball valve could be heard as the PCTB was stroked internally while pulling the PCTB out of the OCB. This further verified that the space out was correct and the internal stroking of the PCTB was occurring in the proper sequence.

The PCTB was removed from the OCB and disassembled. The OCB was then disassembled, ending the testing program.

Discussion:

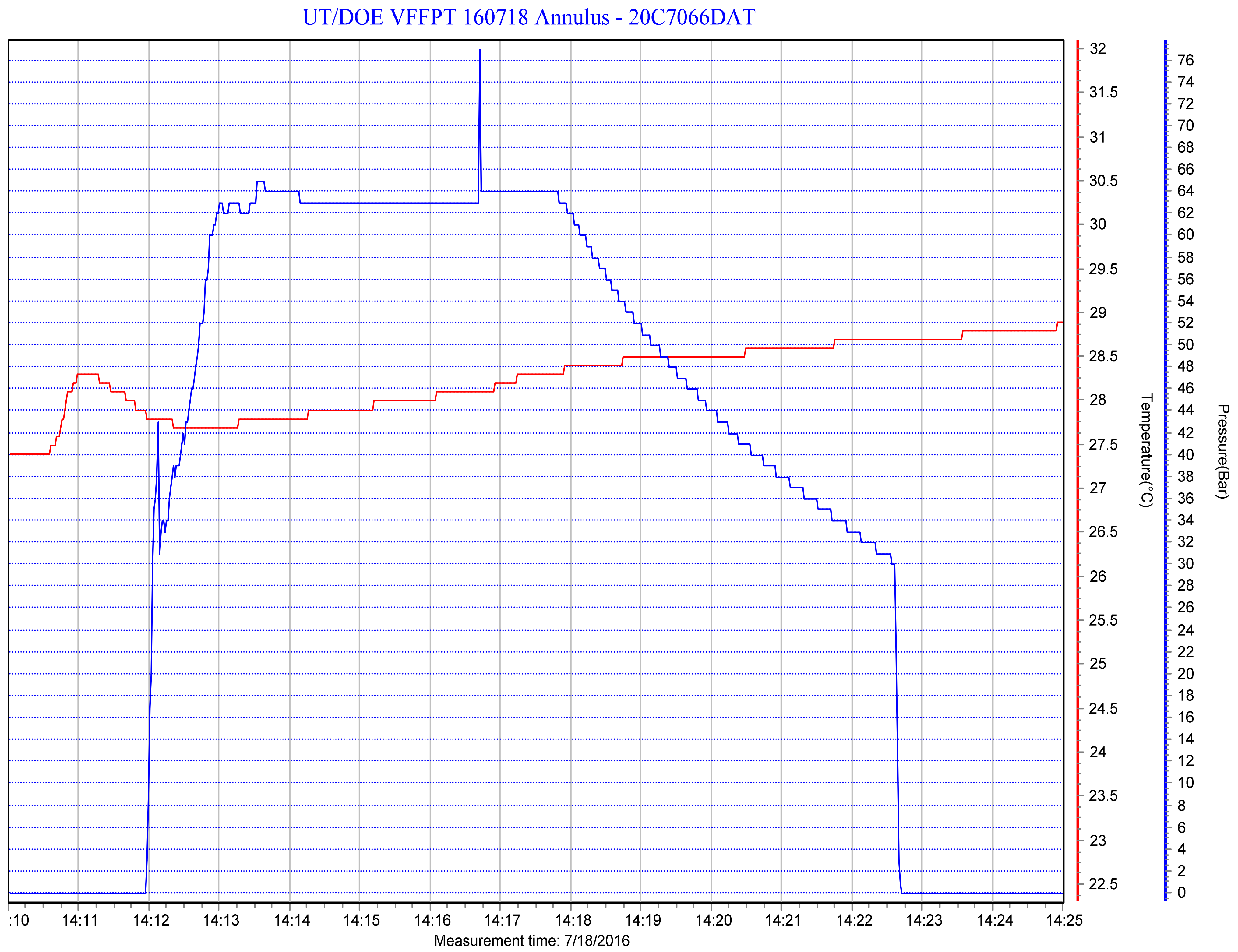
The failure of the PCTB to latch on the first attempt was due to friction caused by performing the test horizontally. When the head sub was made up the second time, the latch sleeve was able to push against the outer latch dogs more evenly and with the power screw effect of the thread the PCTB was seated properly. This type of failure to latch is not likely to occur in the field where everything is done vertically.

Conclusions

1. The double Poly-Pak autoclave plug seal configuration should be deployed in the future.
2. Either the double bevel or large radiused sea sub should be deployed in the future.
3. The PCTB space out, when configured with the new and modified parts, is compatible with the current PCTB BHA.
4. The PCTB functioned quite well during the tests showing no signs of delayed boost and trapping the boost pressure during all of the tests but one.

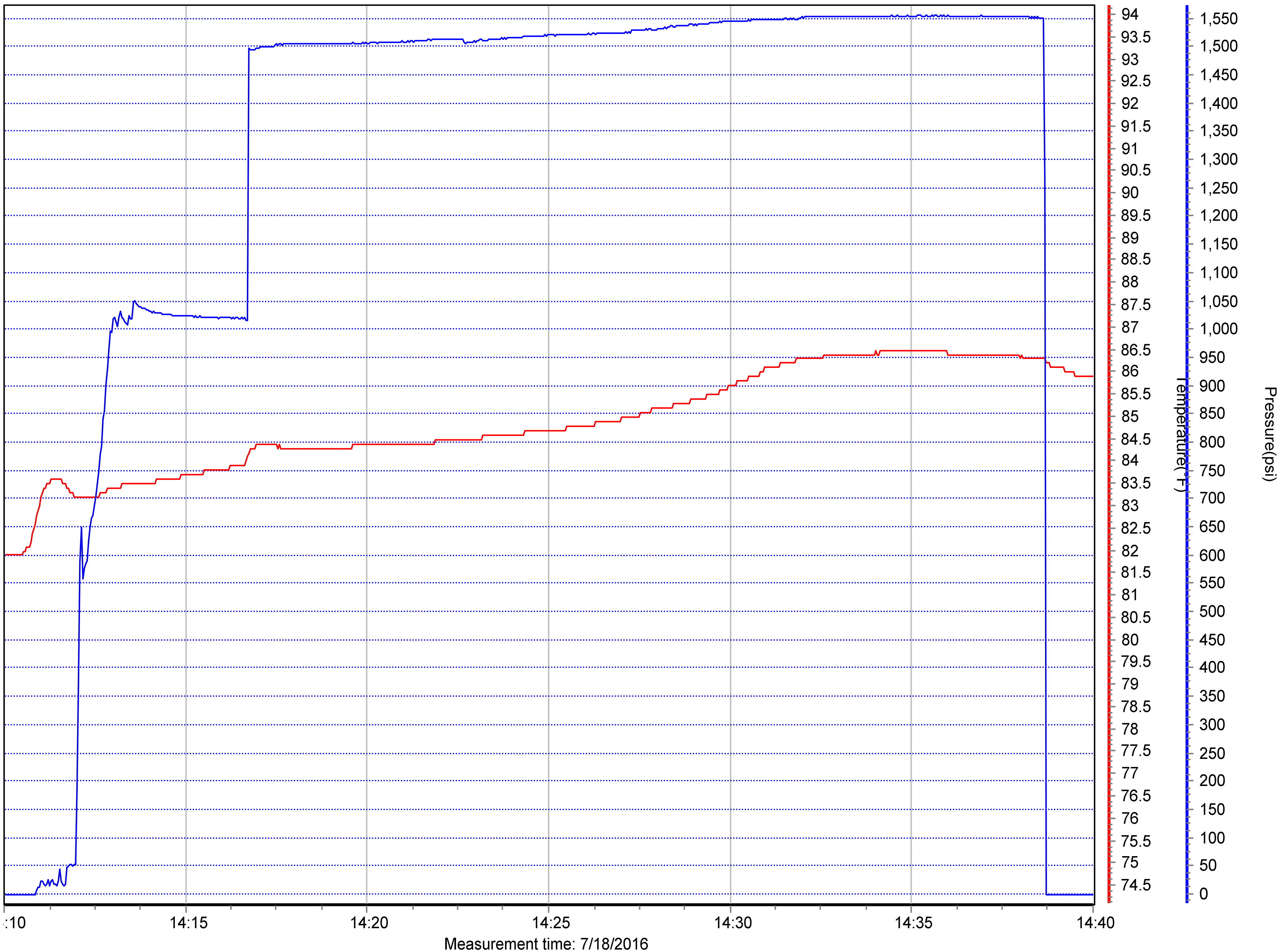
Appendix A
Vertical Full Function Pressure Fish Pill Pressure Data Plots

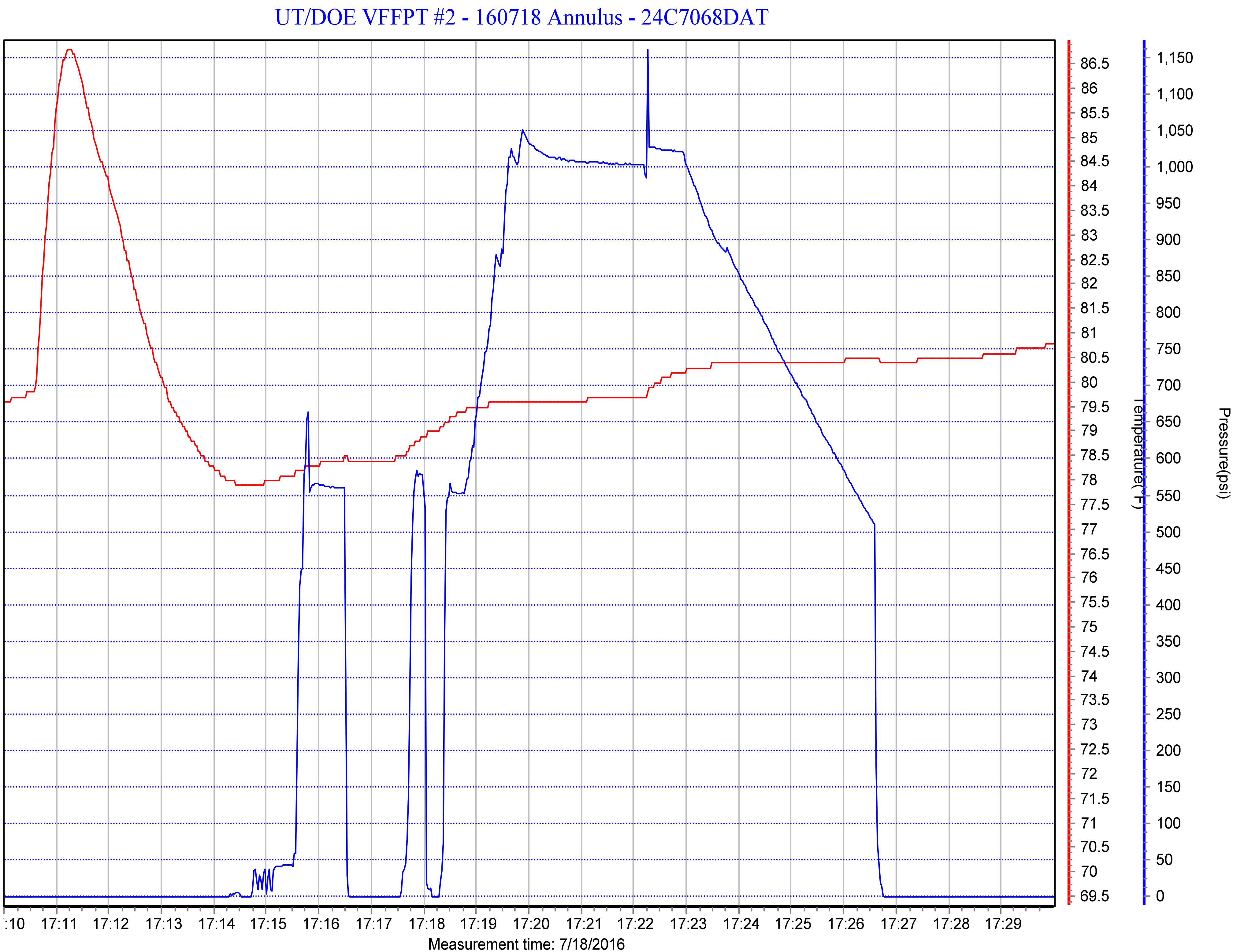
The following plots are of the vertical full function fish pill pressure data collected during the laboratory testing of the PCTB configured with new and modified parts from 18 July through 22 July 2016 at Geotek's facility in West Valley City, Utah. Note that the plots are from raw data. Final plots, with proper annotation, will be distributed as part of the Geotek testing report.

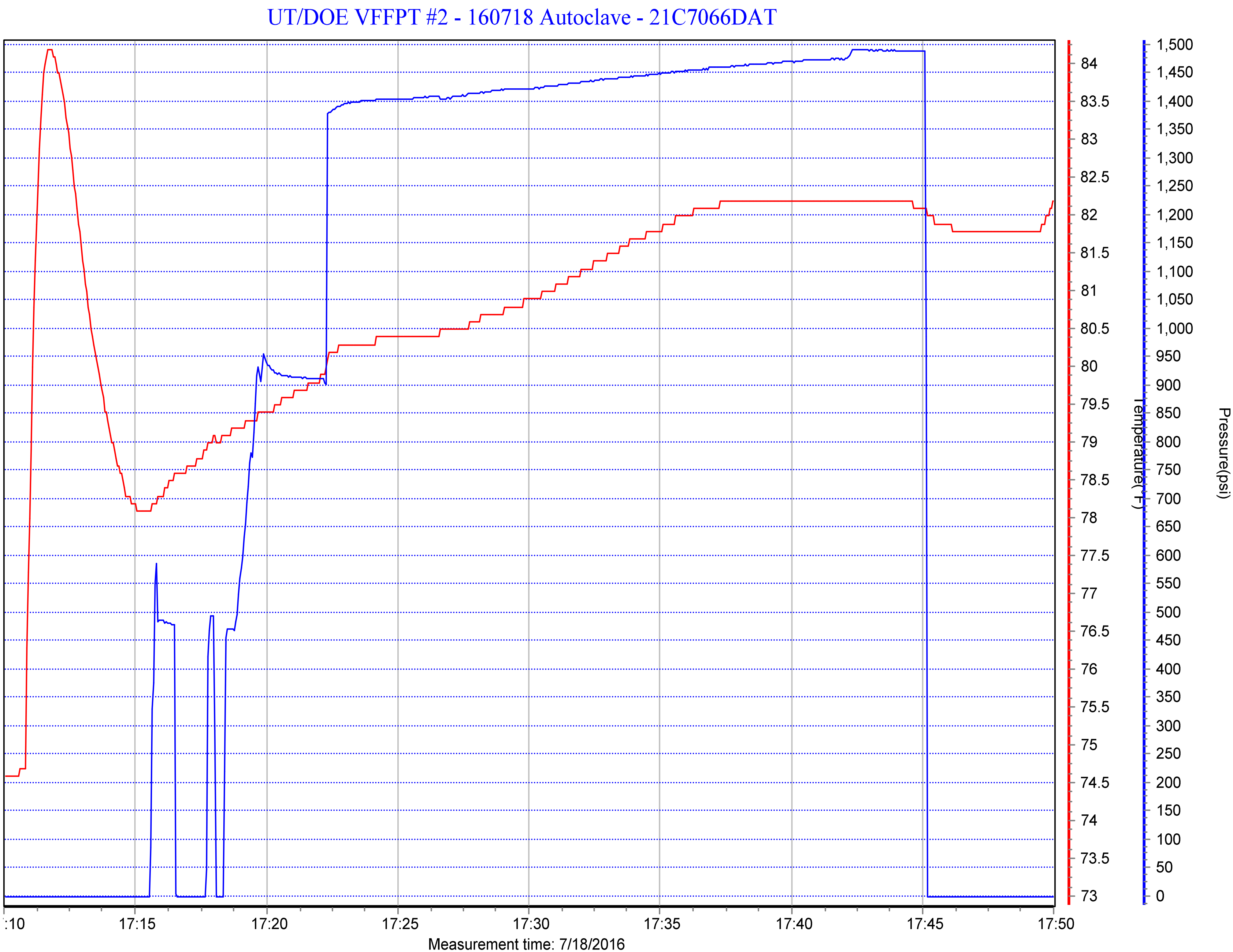


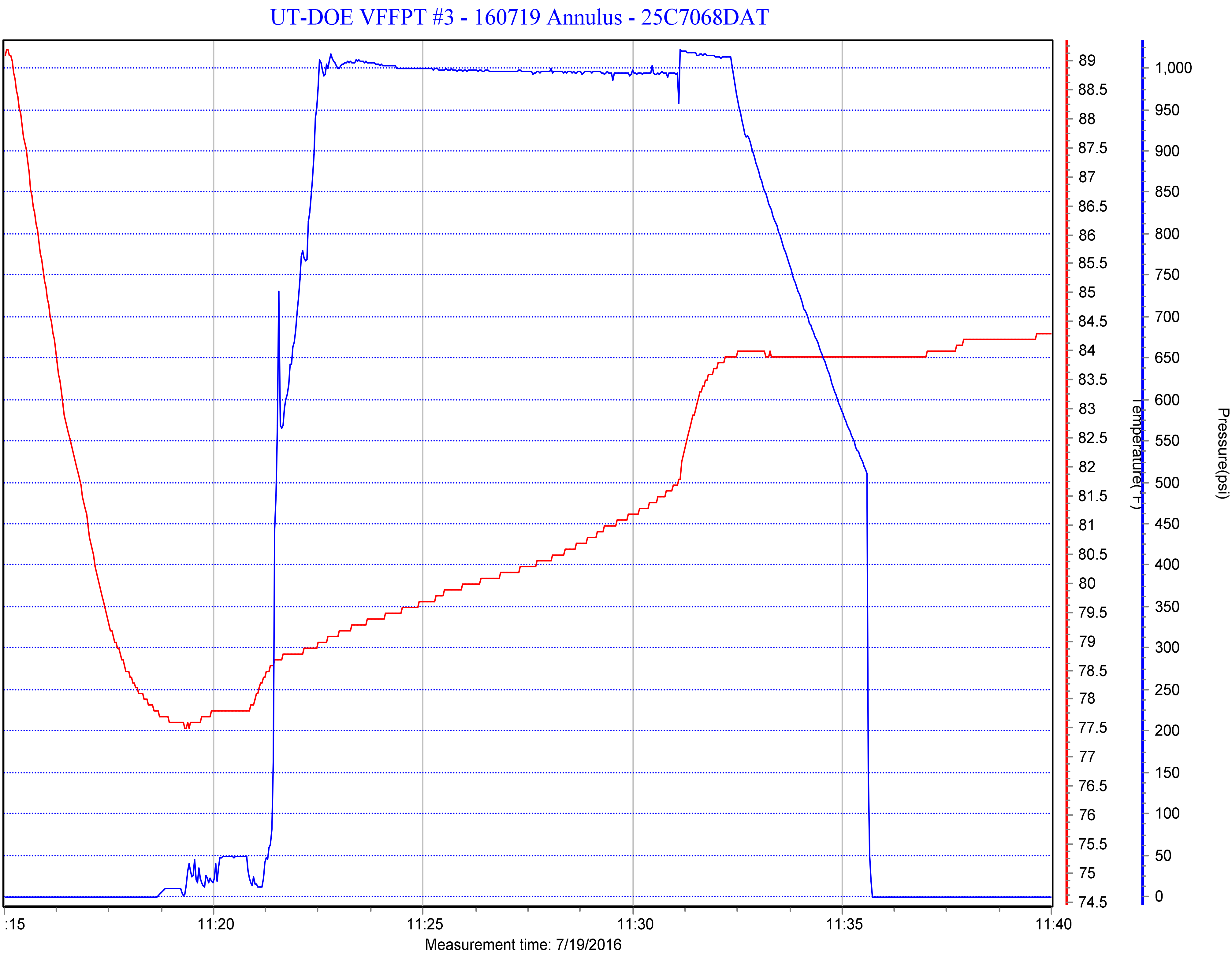
UT/DOE VFFPT 160718 Annulus - 20C7066DAT
Temperature(°C)
Pressure(Bar)
32
31.5
31
30.5
30
29.5
29
28.5
28
27.5
27
26.5
26
25.5
25
24.5
24
23.5
23
22.5
76
74
72
70
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
:10
14:11
14:12
14:13
14:14
14:15
14:16
14:17
14:18
14:19
14:20
14:21
14:22
14:23
14:24
14:25
Measurement time: 7/18/2016

UT/DOE VFFPT #1 - 160718 Autoclave - 23C7068DAT

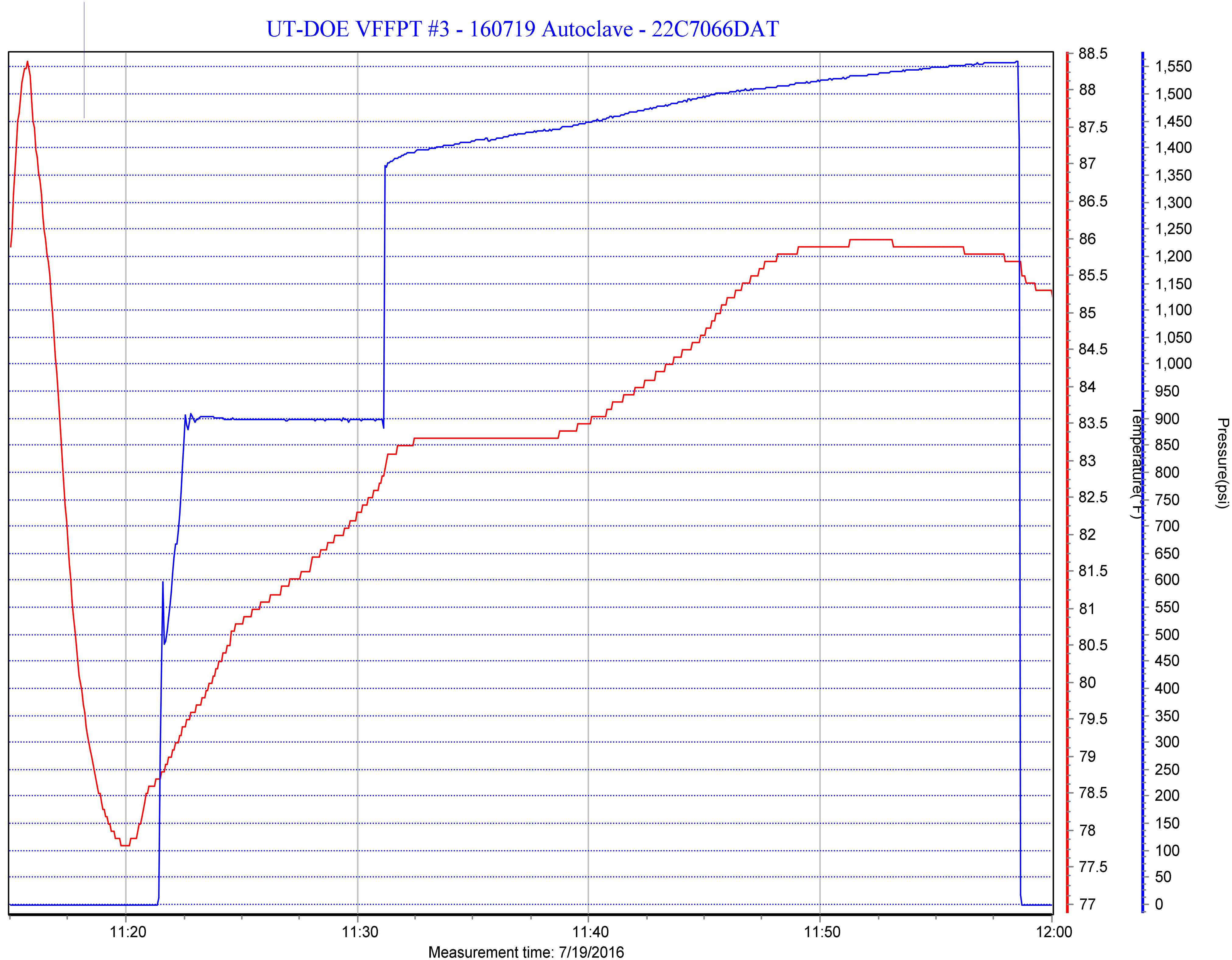



UT/DOE VFFPT #2 - 160718 Annulus - 24C7068DAT
Temperature(°F)
Pressure(psi)
86.5
86
85.5
85
84.5
84
83.5
83
82.5
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
76.5
76
75.5
75
74.5
74
73.5
73
72.5
72
71.5
71
70.5
70
69.5
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
:10
17:11
17:12
17:13
17:14
17:15
17:16
17:17
17:18
17:19
17:20
17:21
17:22
17:23
17:24
17:25
17:26
17:27
17:28
17:29
Measurement time: 7/18/2016

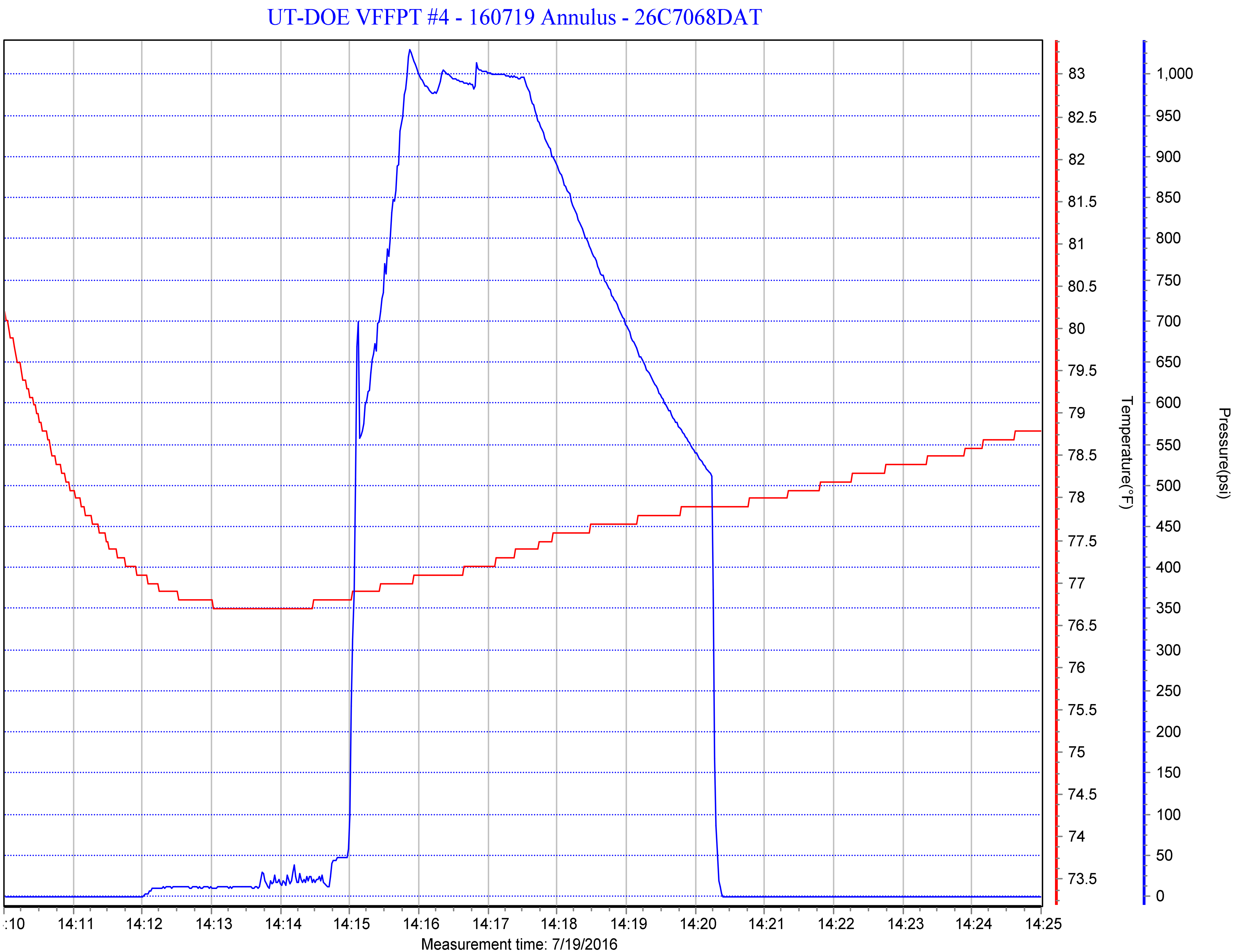

UT/DOE VFFPT #2 - 160718 Autoclave - 21C7066DAT
Temperature(°F)
Pressure(psi)
84
83.5
83
82.5
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
76.5
76
75.5
75
74.5
74
73.5
73
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
:10
17:15
17:20
17:25
17:30
17:35
17:40
17:45
17:50
Measurement time: 7/18/2016



UT-DOE VFFPT #3 - 160719 Annulus - 25C7068DAT
Temperature(°F)
Pressure(psi)
89
88.5
88
87.5
87
86.5
86
85.5
85
84.5
84
83.5
83
82.5
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
76.5
76
75.5
75
74.5
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
:15
11:20
11:25
11:30
11:35
11:40
Measurement time: 7/19/2016

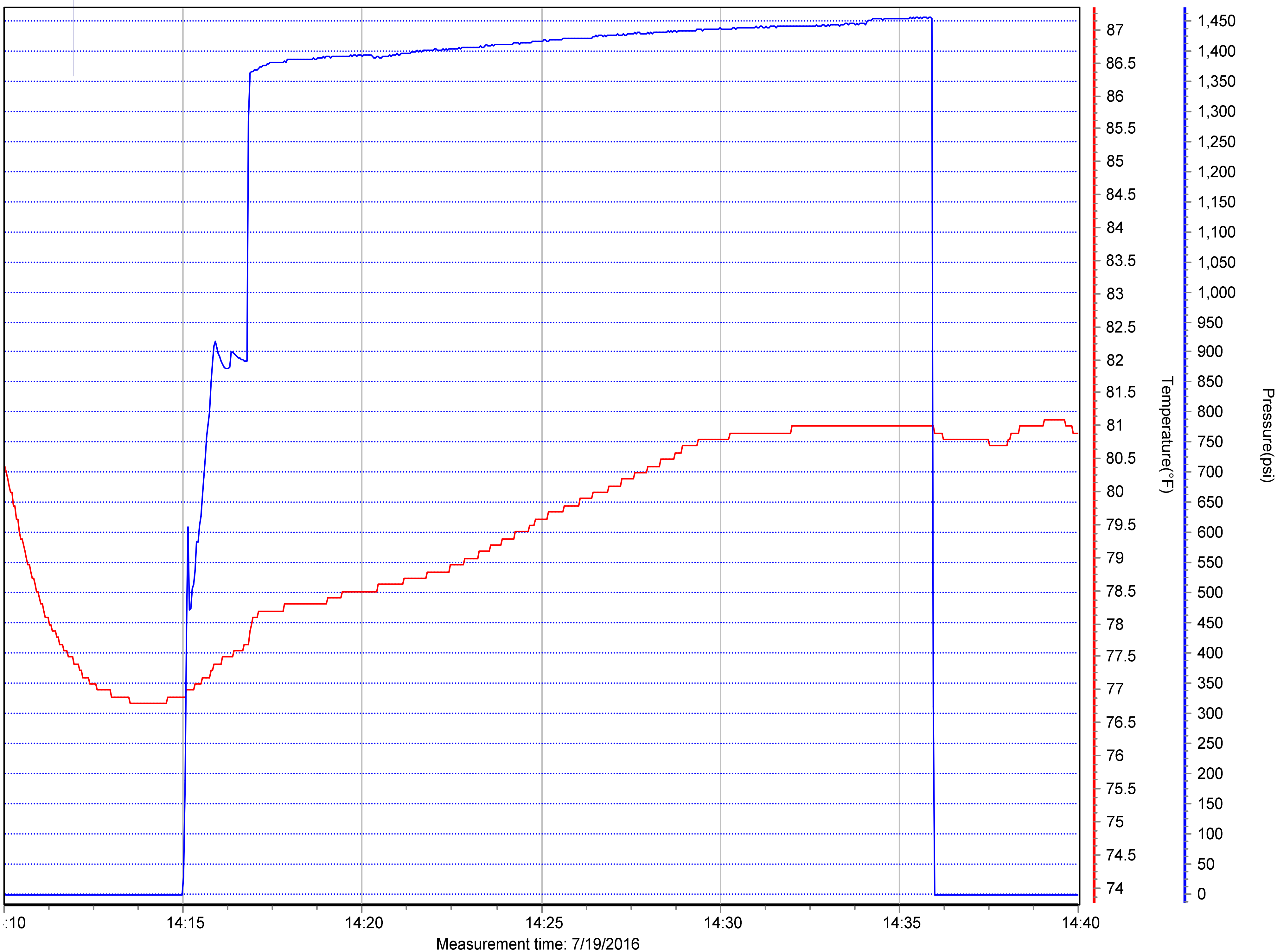


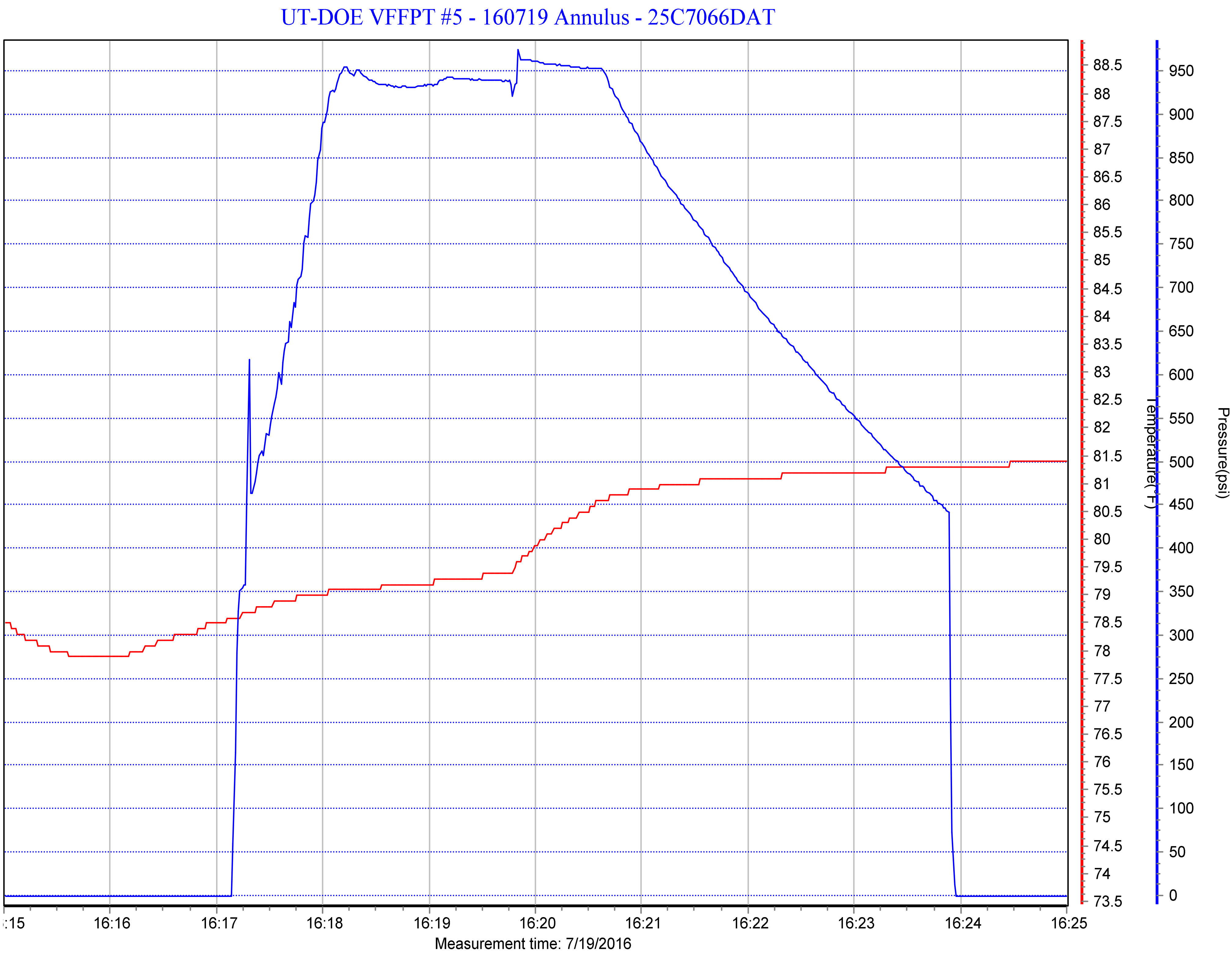
UT-DOE VFFPT #3 - 160719 Autoclave - 22C7066DAT
88.5
88
87.5
87
86.5
86
85.5
85
84.5
84
83.5
83
82.5
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
Temperature(°F)
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Pressure(psi)
11:20
11:30
11:40
11:50
12:00
Measurement time: 7/19/2016



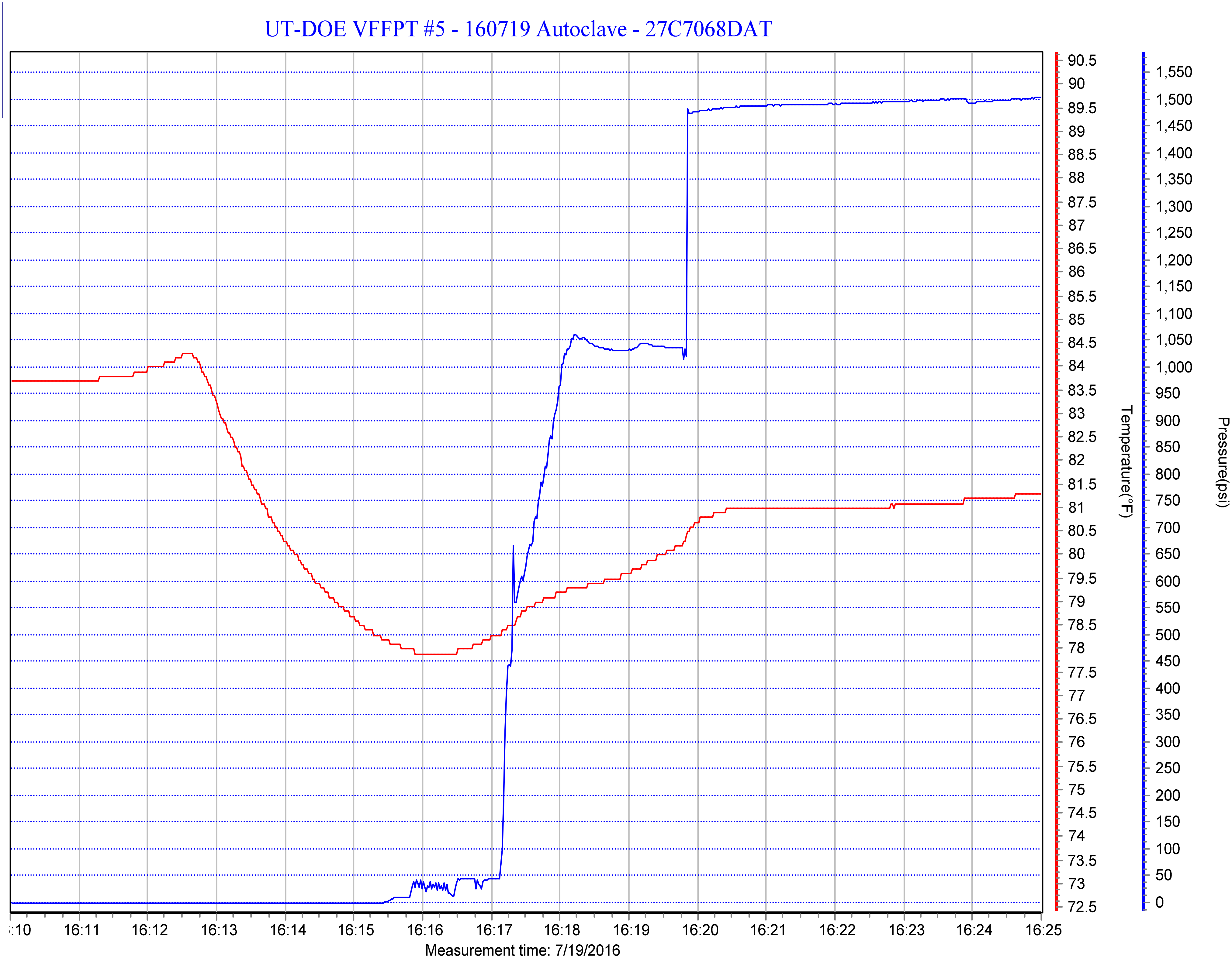
UT-DOE VFFPT #4 - 160719 Annulus - 26C7068DAT
83
82.5
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
76.5
76
75.5
75
74.5
74
73.5
Temperature(°F)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Pressure(psi)
:10
14:11
14:12
14:13
14:14
14:15
14:16
14:17
14:18
14:19
14:20
14:21
14:22
14:23
14:24
14:25
Measurement time: 7/19/2016

UT-DOE VFFPT #4 - 160719 Autoclave - 24C7066DAT



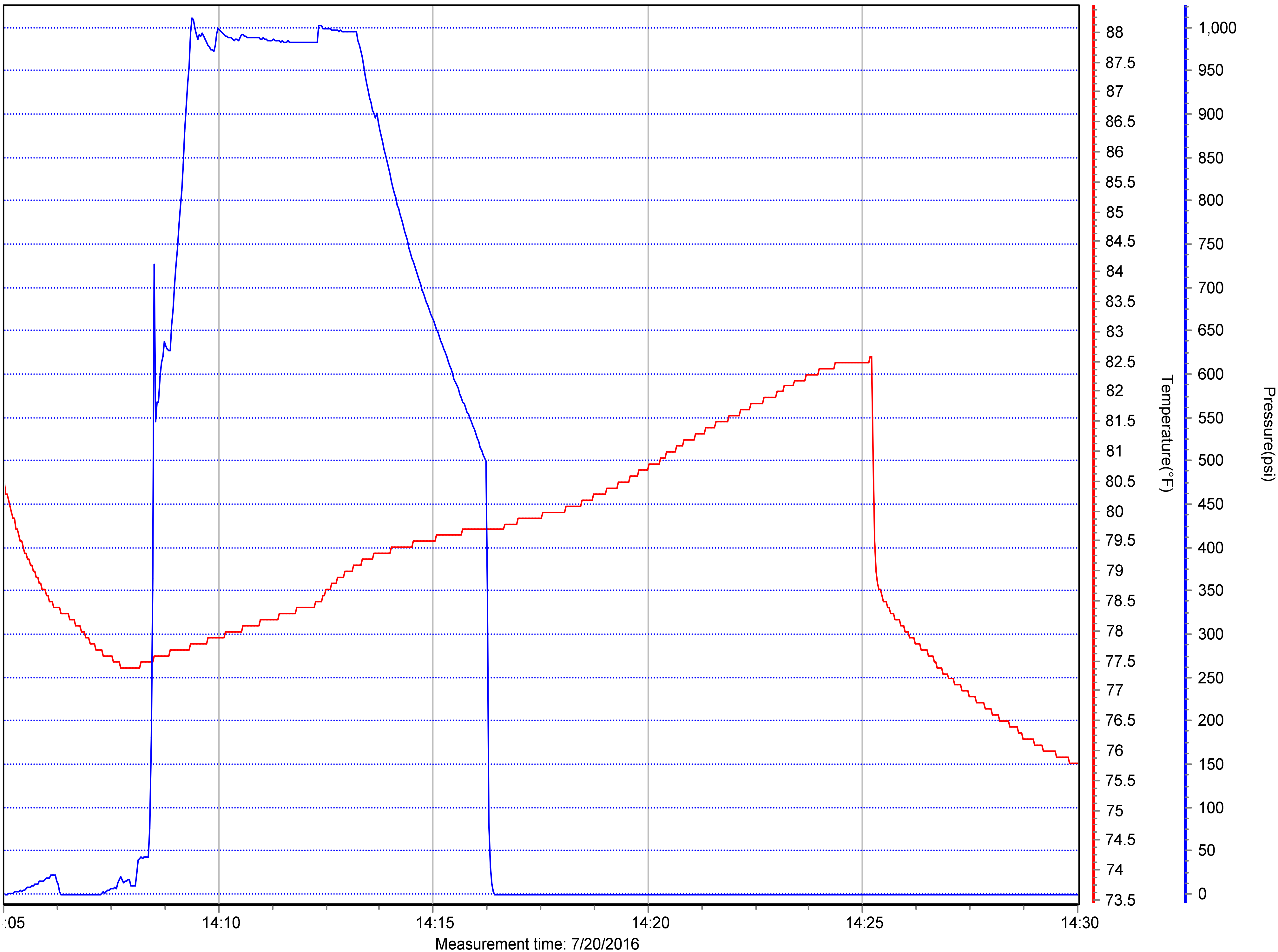


UT-DOE VFFPT #5 - 160719 Annulus - 25C7066DAT
Temperature(°F)
Pressure(psi)
Measurement time: 7/19/2016

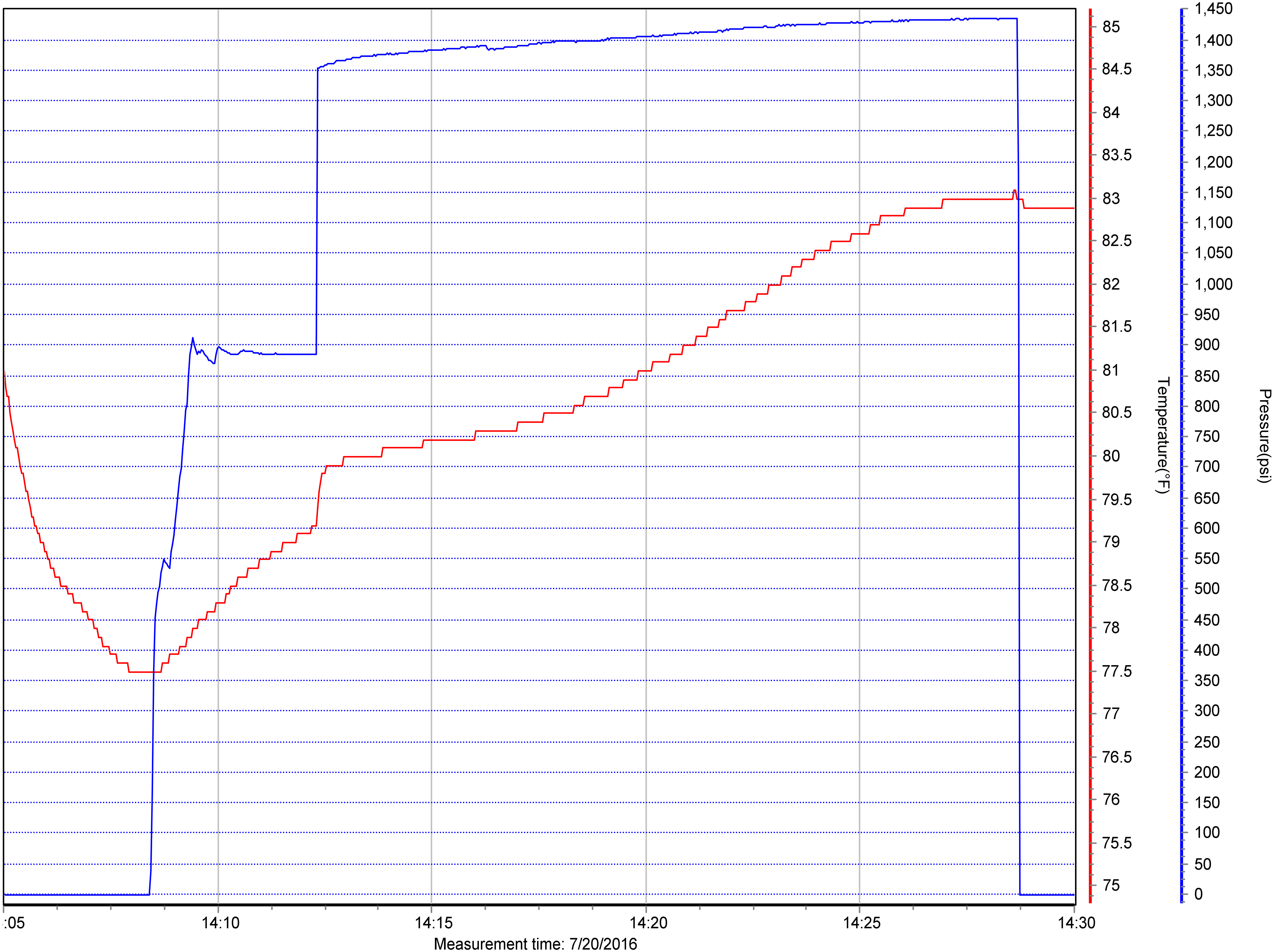


UT-DOE VFFPT #5 - 160719 Autoclave - 27C7068DAT
90.5
90
89.5
89
88.5
88
87.5
87
86.5
86
85.5
85
84.5
84
83.5
83
82.5
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
76.5
76
75.5
75
74.5
74
73.5
73
72.5
Temperature(°F)
1,550
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Pressure(psi)
:10
16:11
16:12
16:13
16:14
16:15
16:16
16:17
16:18
16:19
16:20
16:21
16:22
16:23
16:24
16:25
Measurement time: 7/19/2016

UT-DOE VFFPT #6 - 160720 Annulus - 28C7068DAT

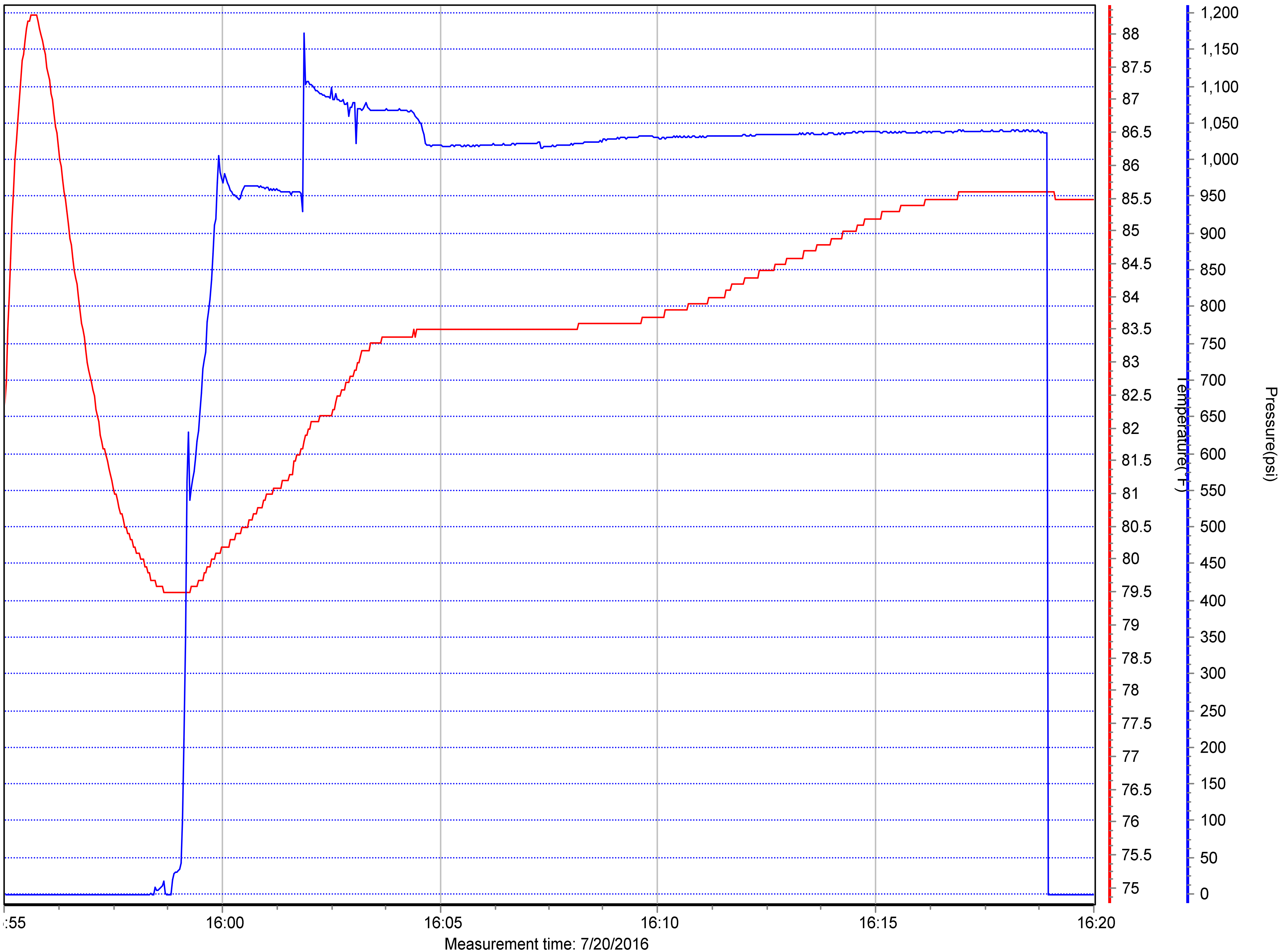


UT-DOE VFFPT #6 - 160720 Autoclave- 26C7066DAT

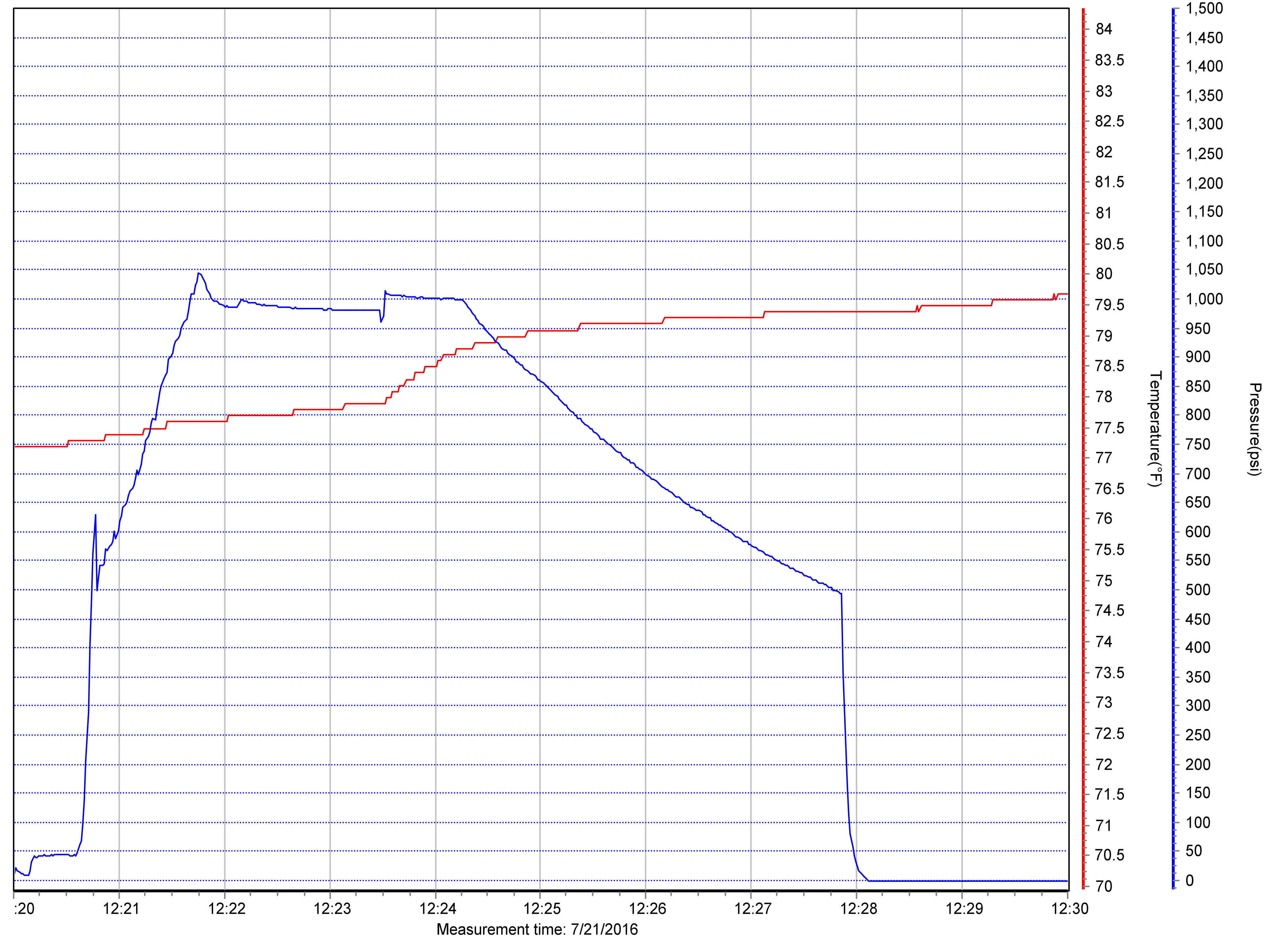


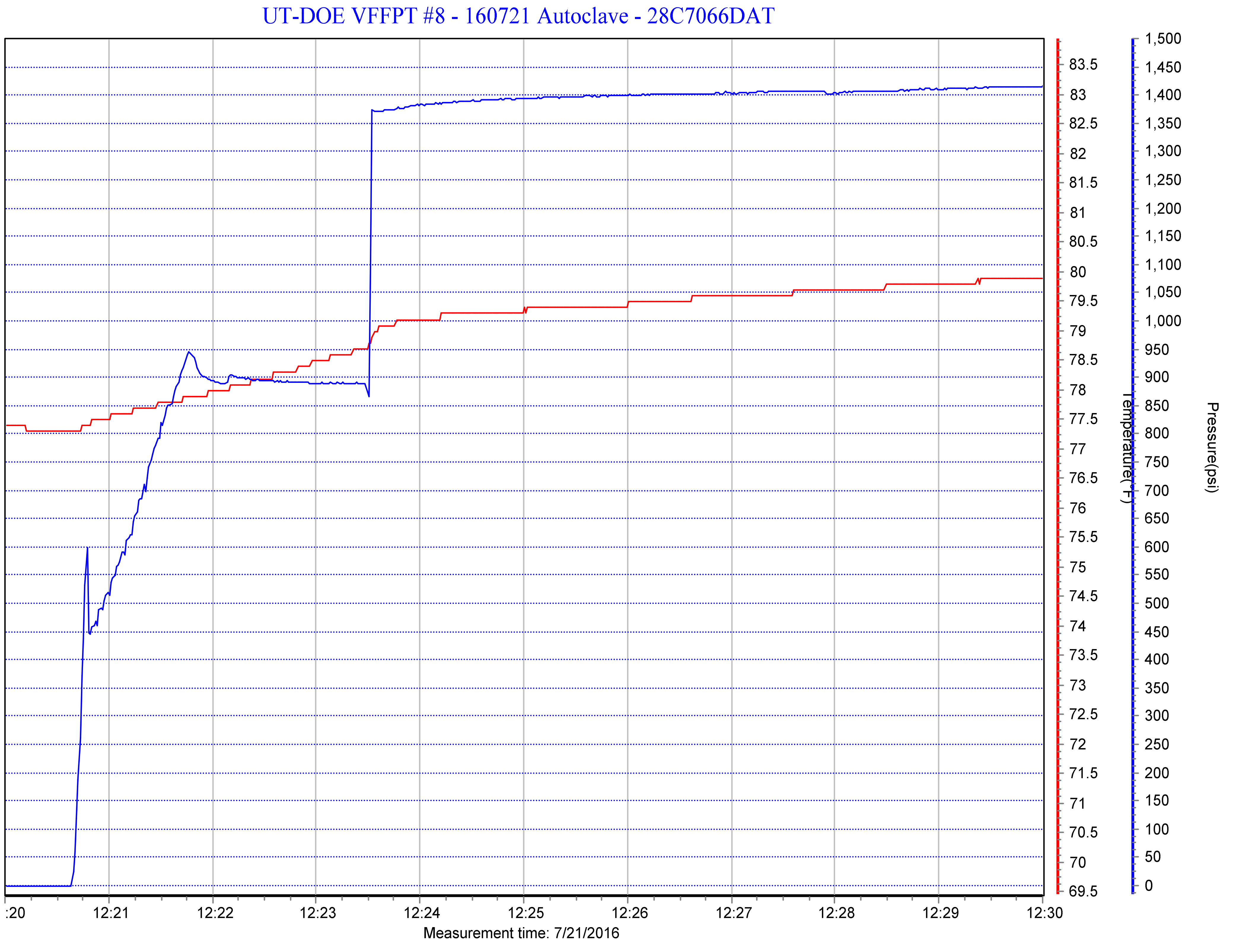

UT-DOE VFFPT #7 - 160720 Annulus - 27C7066DAT
Temperature(°F)
Pressure(psi)
Measurement time: 7/20/2016
:55
16:00
16:05
16:10
16:15
16:20
97
96
95
94
93
92
91
90
89
88
87
86
85
84
83
82
81
80
79
78
77
76
75
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0

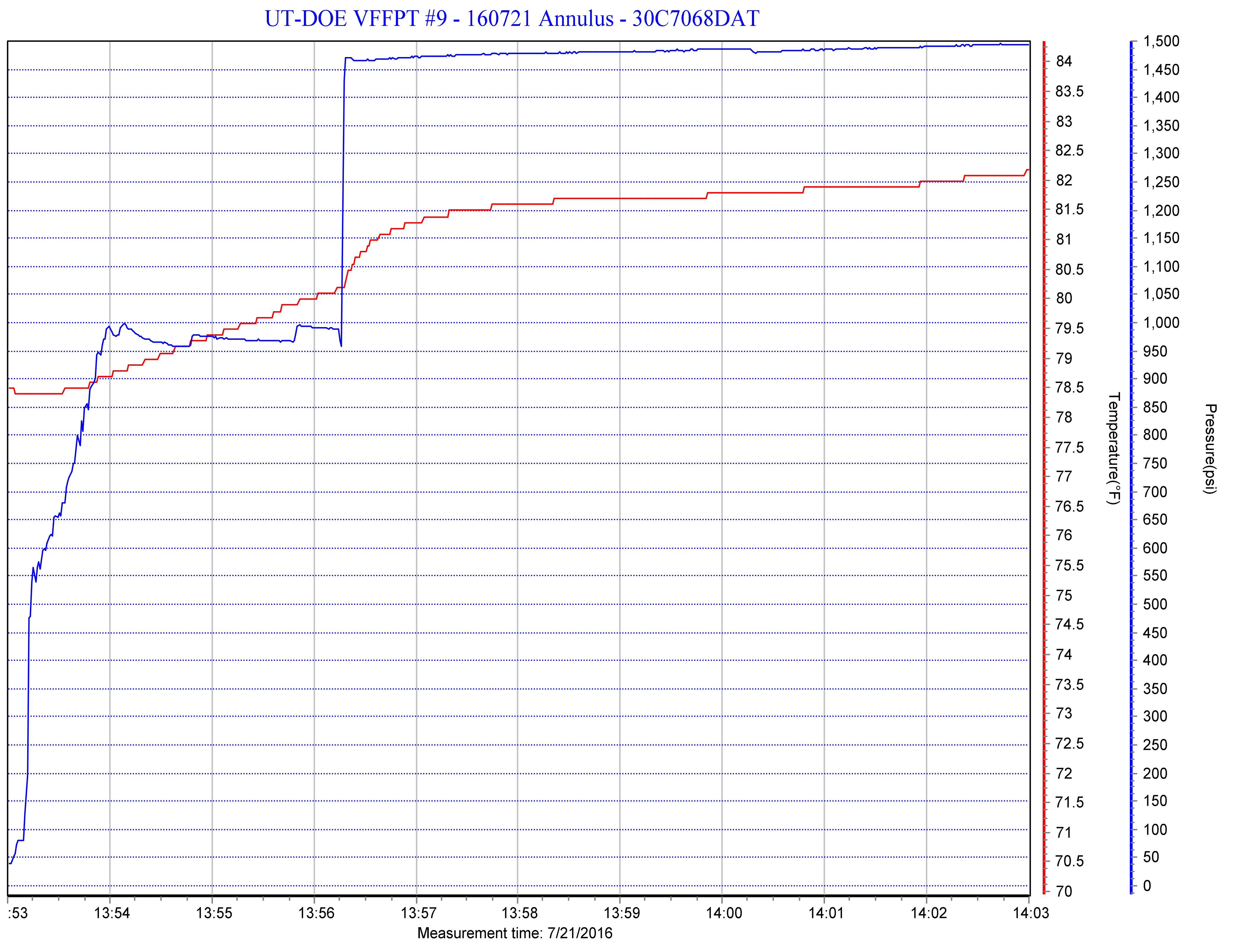
UT-DOE VFFPT #7 - 160720 Autoclave- 29C7068DAT

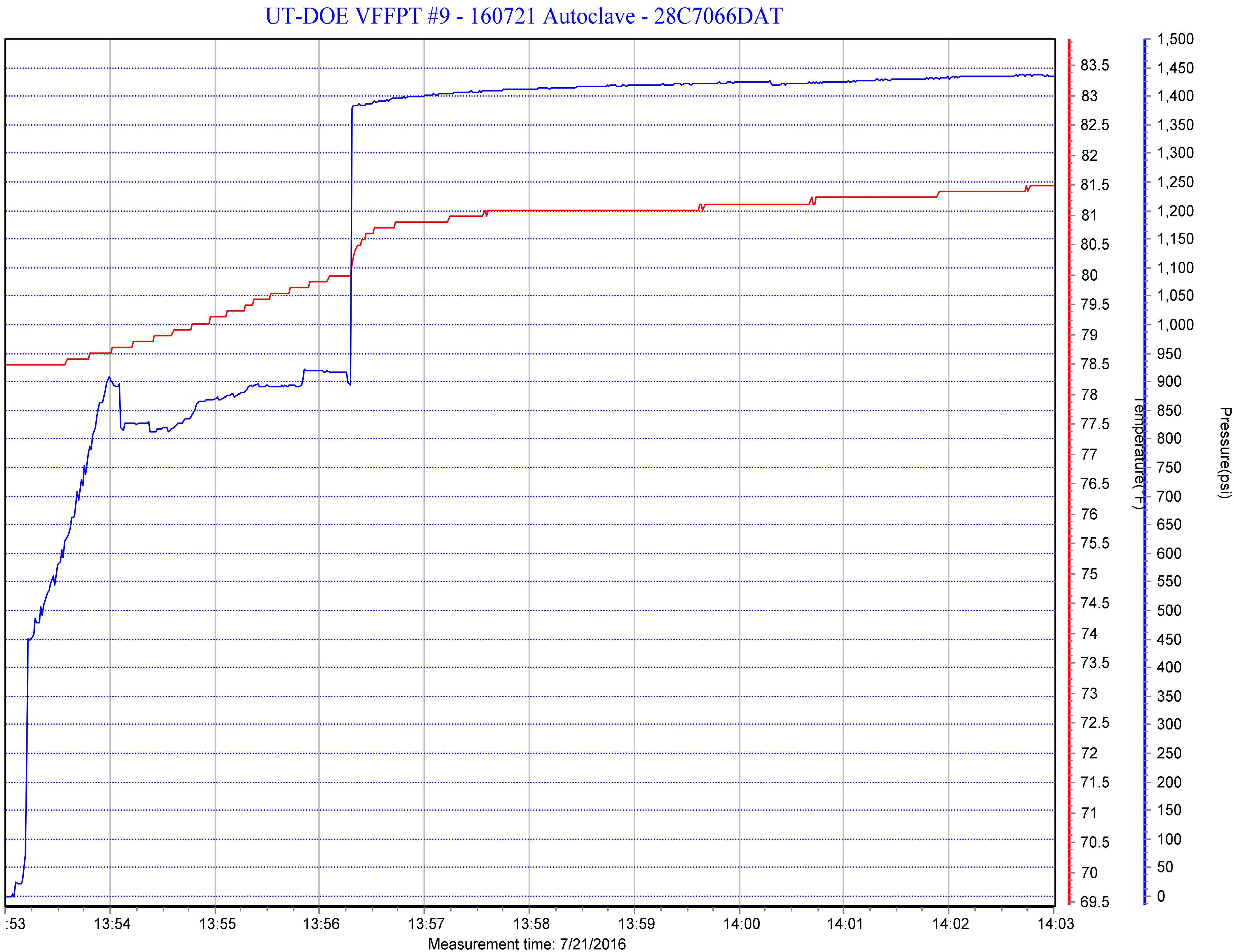


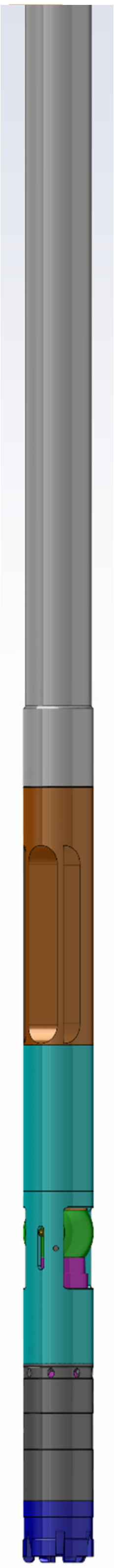
UT-DOE VFFPT #8 - 160721 Annulus - 30C7068DAT




UT-DOE VFFPT #8 - 160721 Autoclave - 28C7066DAT
Temperature(°F)
Pressure(psi)
83.5
83
82.5
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
76.5
76
75.5
75
74.5
74
73.5
73
72.5
72
71.5
71
70.5
70
69.5
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
:20
12:21
12:22
12:23
12:24
12:25
12:26
12:27
12:28
12:29
12:30
Measurement time: 7/21/2016


UT-DOE VFFPT #9 - 160721 Annulus - 30C7068DAT
Temperature(°F)
Pressure(psi)
Measurement time: 7/21/2016
:53
13:54
13:55
13:56
13:57
13:58
13:59
14:00
14:01
14:02
14:03
70
70.5
71
71.5
72
72.5
73
73.5
74
74.5
75
75.5
76
76.5
77
77.5
78
78.5
79
79.5
80
80.5
81
81.5
82
82.5
83
83.5
84
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1,000
1,050
1,100
1,150
1,200
1,250
1,300
1,350
1,400
1,450
1,500


UT-DOE VFFPT #9 - 160721 Autoclave - 28C7066DAT
Temperature(°F)
Pressure(psi)
83.5
83
82.5
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
76.5
76
75.5
75
74.5
74
73.5
73
72.5
72
71.5
71
70.5
70
69.5
1,500
1,450
1,400
1,350
1,300
1,250
1,200
1,150
1,100
1,050
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
:53
13:54
13:55
13:56
13:57
13:58
13:59
14:00
14:01
14:02
14:03
Measurement time: 7/21/2016



HYBRID PRESSURE CORING TOOL WITH BALL VALVE MARK III (PCTB III)

2016 PRE-SEA TRIAL TESTS

GEOTEK LTD DOCUMENT NO. UT2-2016 (R1)

PREPARED FOR:

UNIVERSITY OF TEXAS

PREPARED BY:

GEOTEK CORING INC
3738 West 2340 South, STE C
West Valley City, Utah 84119
United States

T: +1 385 528 2536
E: info@geotekcoring.com
W: www.geotekcoring.com

ISSUE	REPORT STATUS	PREPARED	APPROVED	DATE
R1	Final Report	JA	JA/MM	15-Sep-2016

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

The Pressure Coring Tool with Ball Valve Mark III (PCTB III) is an improved version of the original PCTB core barrel that was developed by Aumann & Associates, Inc. The PCTB II tool was developed in 2013 and tested that year in offshore coring in China. The next year it was again tested at the Catoosa Test Facility for the DoE. During further development the PCTB II was utilized successfully to recover methane hydrate bearing cores during operations offshore Japan and China in 2015. The PCTB tool is a wireline retrievable system designed to recover a 2.00 in. diameter x 3.0 m long core at pressures up to 5000 psi. It is also compatible with, and can transfer pressurized cores to the Geotek Pressure Core Analysis and Transfer System (PCATS) for analysis of the core under pressure thereby preventing loss of pressure sensitive materials such as methane hydrate, expanding gas, oil or other fluids as well as changes in mechanical properties due to pressure reduction.

The PCTB II Onshore Test Program at the Schlumberger Cameron Test and Training Facility (CTTF) was designed to test the effectiveness and efficiency of drilling and coring with the PCTB II pressure core barrel and as a qualification test prior to proposed 2017 offshore operations for the DoE-UT in the Gulf of Mexico. The CTTF test program did, in fact, largely confirm that the tools are “fit for purpose” for future offshore coring operations as detailed in this report. However, the CTTF test program also revealed a potential issue with a late nitrogen boost caused by an incomplete stroke of the tool. This caused the firing of the nitrogen boost after the PCTB was raised most of the way out of the hole or failure of the tool to hold pressure at all.

Since the land test, a variety of modifications were made in an attempt to improve performance. These changes were focused on preventing possible hang up of the upper seal of the autoclave, reducing the flow of debris and pipe scale into the inner workings of the PCTB, and preventing collapse of the core liner at higher flow rates. Additional small changes were made to improve latch performance. The modified design is has been named PCTB III. In addition, a special pseudo core liner and inner tube were designed and fabricated that incorporated DST’s to measure and record the collapse pressures on the core liner and inner tube during flow tests to be conducted offshore during a Fugro pressure coring operation offshore China. The new parts and a special test fixture and control console required for the Pre-sea Trial Tests were completed and trial assembled without any issues.

The primary goal of this Pre-sea Trial Test program was to ensure proper function and improved performance of the PCTB III with the above modifications before committing to the Marine Trials. Four tests were developed to fully test the modified tool. The tests included 1) Upper Autoclave Seal Sub Test, 2) Vertical Full Function Pressure Test (VFFPT), 3) Horizontal Space-out Test and 4) Flow Test. Full description of the tests are provided in the body of this report.

The VFFPT test and Horizontal Space-out Tests were completed during the week of July 18, 2016. Representatives Tom Pettigrew and Steve Phillips, from UT/DoE witnessed the tests conducted at Geotek Coring Inc (GCI) facilities in West Valley City, Utah. The tests were successfully completed and revealed that the PCTB III is sufficiently reliable to be further tested and used in the Marine Trial. The results of the tests are detailed in the body of this report and the Appendix.

Unfortunately, customs delays in China and operations on board the drill ship prevented the Flow Test from being carried out. It is recommended that this test be completed during the Marine Trial.

2. DESCRIPTION OF THE TESTS

2.1. UPPER AUTOCLAVE SEAL SUB TEST

This test was an attempt to measure the axial force of the upper autoclave seal as it entered the bore of the Seal Sub. The original PCTB design incorporated two large cross-section o-rings which entered a rather steep ramp in the seal sub bore. It was believed that the o-rings could sometimes jam as they entered the bore and result in the incomplete stroke of the tool observed during the full function pressure tests and also occasionally in operations. Extrusion and cutting of the o-ring seals had occasionally been observed historically as well. For this reason a lip seal was selected to replace one of the o-rings during the PCTB II upgrade. The current modification includes changing to two lip seals and eliminating the large cross-section o-rings completely as well as reducing the angle of the entrance ramp with either a large radius or much lower 10° angle entry cone. The Full Function Pressure Test actuator in conjunction with the standard pressure control section was used to pull the inner tube plug, containing the upper autoclave seals, up and into the test Seal Sub bore. This was the best solution as it utilized the normally assembled parts to conduct the test. It also provided the normal upward vertical movement of the inner tube plug into the seal bore. It also easily permitted the test parts to be immersed in water during the tests.

During the test, the internal pressure of the actuator is slowly increased. The pressure is carefully monitored and the maximum pressure is noted. The force required can be calculated simply by multiplying the pressure by the area of the cylinder. Friction within the cylinder was not considered significant. The stated effective area 0.69 sq.in. The tare weight of the parts lifted was measured at 180 psi (the equivalent of 124 lbs) which must be subtracted from the cylinder pressure readings made during the test to arrive at the net force required for seal entrance into the bore. The original design, dual lip seal and the two new Seal Sub designs were tested. No lubricant was applied to the seals or test parts. The pull test was repeated ten times for each configuration for a good sample size.

2.2. VERTICAL FULL FUNCTION PRESSURE TEST (VFFPT)

The PCTB would sometimes lockup as it was manipulated during the horizontal Full Function Pressure Test (FFPT). This prevented full stroke and actuation of the PCTB. It was never clearly understood if these failures were due to the horizontal test setup or a design weakness inside the PCTB tool itself. The VFFPT is designed to eliminate the possibility of gravitational forces or the horizontal nature of the test setup contributing to or causing the observed lockups. A new test fixture was designed to safely conduct the VFFPT. The test fixture incorporates two large bearings attached to a standard lifting clamp. This fixture is securely mounted to a forklift truck as shown in the photo below. The bearings act as a hinge and enable the PCTB tool to be assembled and attached to the VFFPT fixture horizontally and then safely raised into the vertical test position simply by lifting the forks on the lift truck.

Figure 1, VFFPT Test Fixture mounted to a forklift. Note large bearings and lifting clamp.

Figure 2, VFFPT Test Fixture being raised to vertical position for test.

A hydraulic cylinder integrated into the balance chamber mounted to the top of the tool is used to simulate the wireline pulling tool function. Hydraulic pressure is used to stroke and activate the tool in a more controlled fashion than the come-a-long used with the original FFPT. A linear transducer is also integrated into this test fixture to easily and safely provide real-time observation as well as recording of the stroke position. The PCTB is fitted with a cylindrical cap to seal the bottom of the tool and extends over to seal the windows in the ball valve housing to providing a pressure chamber that simulates the area in the BHA below the PCTB.

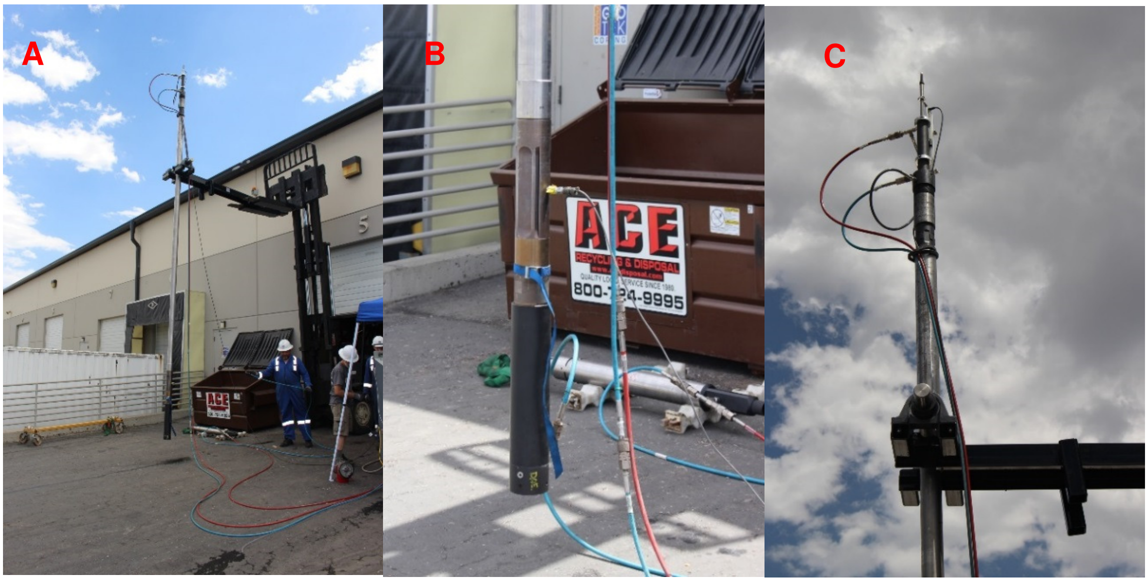


Figure 3: Setup of vertical full-function pressure test (VFFPT). A) PCTB in vertical orientation. B) Bottom cap with water lines attached and accumulator in the background. C) Actuating mechanism at top of PCTB.

The upper and lower chambers are connected via hydraulic hoses so that equal pressures are maintained above and below the PCTB thus replicating the ID of the outer core barrel assembly.

A new pressure test console was prepared for the VFFPT. It incorporates the hydraulic pump, gauges, linear transducer readout, and a new hydraulic system to reliably and accurately control the rate of depressurization when simulating the wireline trip out of the hole. A pressure transducer is included to monitor the autoclave pressure in real time. An electronic A/D converter with USB computer output is available to make a computer record of the output of both the linear and pressure transducers. Digital Storage Tags (DST's) are placed within the autoclave and in the simulated annulus between the cap and the bottom of the PCTB to record those pressures as well.

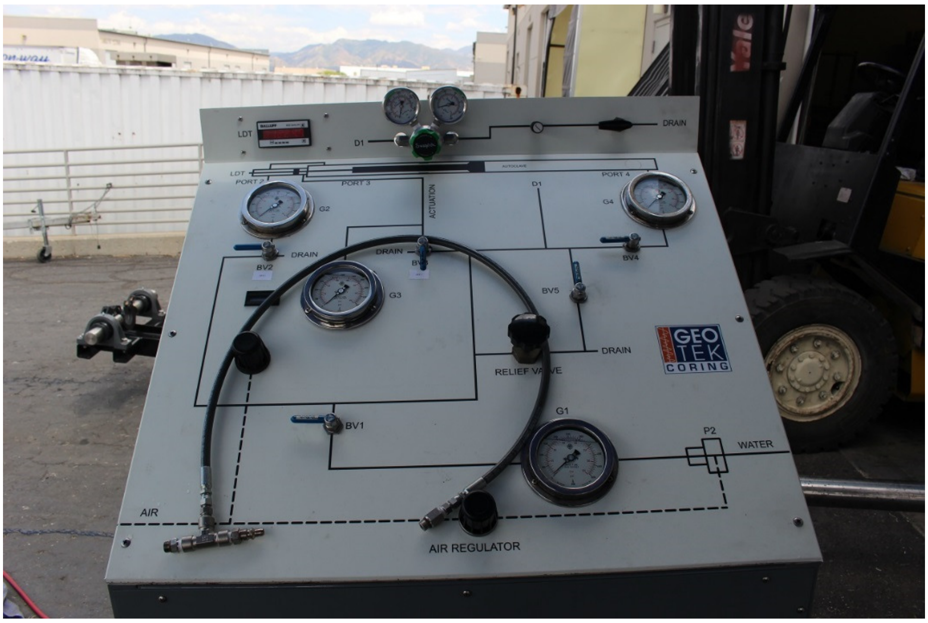
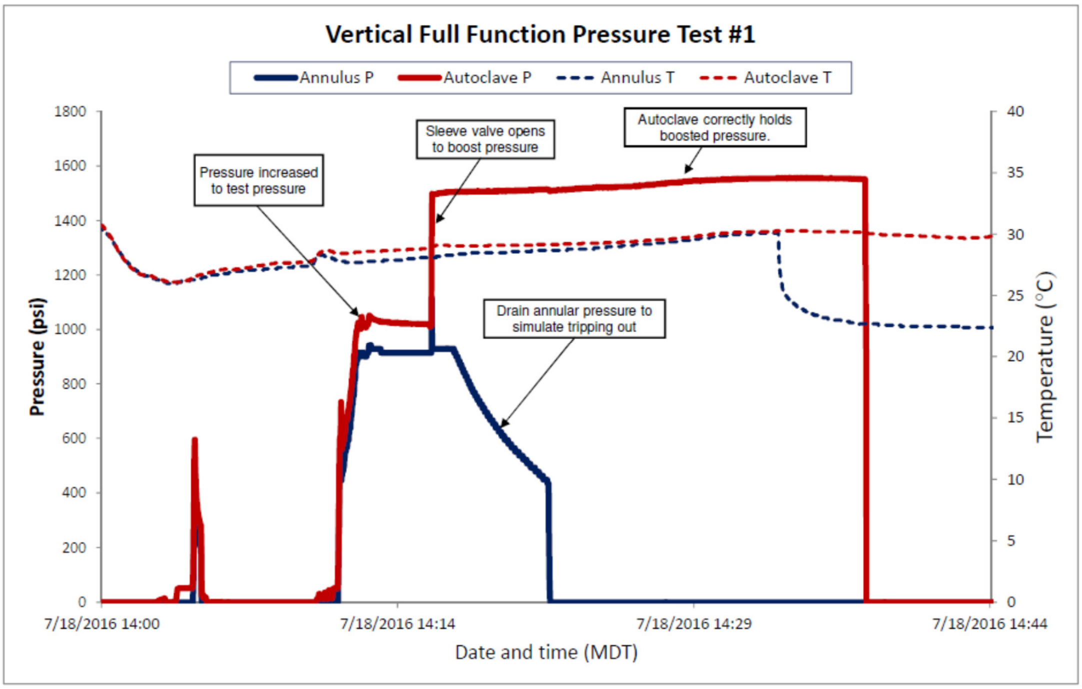


Figure 4, Pressure Test Console with linear transducer readout (top left) and new depressurization controls (top middle and right).

To conduct a VFFPT, the PCTB autoclave is assembled and hydraulically pressure tested as is normally done for an operation. The reservoir chamber in the pressure control section is filled with nitrogen and the regulator set to the desired boost pressure and function tested. The pressure control section is assembled to the autoclave. Then the upper balancing chamber and lower pressure test cap are installed. Hoses are used to connect the upper to lower chamber and to the new pressure test console and to an accumulator used to smooth out the pulses from the pump. The pressure transducer is attached to the port in the drive sub and the linear transducer is connected to its readout box. The PCTB is attached to the gimbaled lifting clamp and raised vertically using the forklift. The tool and the annulus are filled with water and pressure increased to the static test pressure (~1000 psi used for this series of tests) via the pump in the pressure test console. Pressure is applied to the actuator cylinder at the top of the assembly to simulate the pulling of the wireline to trigger ball valve closure and N2 boost from the pressure control section. After the pressure boost is observed, the pressure in the annular chambers is slowly lowered to simulate coming out of the hole. An example DST pressure chart shows correct operation.



2.3. HORIZONTAL SPACE OUT TEST

The horizontal space-out test is performed by assembling the bottom-hole assembly (BHA) horizontally and then sliding the complete PCTB inner barrel assembly into the BHA from the top. The BHA consisted of the cutting shoe bit, bit sub, outer core barrel, landing sub, top sub, and head sub. The PCTB III in the cutting shoe configuration was manoeuvred horizontally with a forklift and inserted into the top end of the BHA until the cutting shoe protruded from the bottom of the drill bit. Normally in a vertical orientation the tool would normally be suspended from the wireline allowing the dogs to retract and the tool to pass through the restriction in the head sub. In the horizontal position dogs in the upper part of the tool had to be manually covered and retracted to be inserted into the BHA. After the latch is locked in position, the cutting shoe is pushed up to check that the PCTB III is properly latched in the BHA. The pulling tool is then used to simulate pulling the tool after a coring run to check for proper PCTB III operation including ball closure and release from the BHA.

2.4. FLOW TEST

The purposes of the PCTB flow test is a) to characterize the pressure drops within the BHA and PCTB, b) to measure and compare the recorded flowing pressures between the standard PCTB and the modified PCTB III, and c) to test the PCTB III modifications designed to eliminate core liner and inner tube collapse.

An instrumented core liner was designed and fabricated. It replaces the standard core liner and inner tube during the flow tests. The instrumented core liner houses integral DST pressure recorders strategically located along its length to monitor and record the pressure between the core liner and the core tube as well as the outside of the core tube. The instrumented core liner would be installed in a standard PCTB and in a modified PCTB III for comparison of the pressure records. Incremental flow would be established with the BHA hanging just below the rotary table at rates from 100 gpm to a maximum of 500 gpm (or maximum capability of the pump) with the instrumented core liner in place recording the pressures.

The China flow tests were to be undertaken by Geotek with the cooperation of Fugro on a “best effort” basis, based on timely delivery of the instrumented core liner and modified PCTB III parts, as well as an appropriate opportunity arising during the China operations to perform the tests. It was planned that a Fugro PCTB would be used for the China flow test and updated with the DOE PCTB III parts. The tool is nearly identical to the DOE PCTB III except for the upper assembly being shorter and the smaller BHA ID at the upper end. Testing with the Fugro PCTB should provide nearly identical results to the DOE PCTB III. It was anticipated that the standpipe pressure at the surface may be higher in the Fugro test due to the smaller ID at the upper end of the Fugro BHA. Fugro also does not have a Face Bit Assembly so the tests could only be carried out using the Cutting Shoe Assembly.

3. TEST RESULTS

3.1. UPPER AUTOCLAVE SEAL SUB TEST

The original o-ring design and the newer lip seals were tested in the three Seal Sub configurations including the original 35° seal entry bevel, the radiused seal entry and a 10° seal entry bevel. This results in a matrix of six types of tests. Each test was repeated ten times. The average of the results are summarized in the table below. The chart shows the results with the tare weight of the suspended parts subtracted.

		Seal Sub Type		
		Original 35° Bevel	*Radiused*	*10° Bevel*
		Force (lbs)		
Seal Type	*O-ring*	133	55	19
	PolyPak	79	63	17

The forces measured during this test eliminate the possibility that this seal is not likely the reason for the tool hanging up in previous full function pressure tests or during operations. However, the results do show that's a significant reduction in the seal entry force can be obtained if the new 10° bevel is used.

3.2. VERTICAL FULL FUNCTION PRESSURE TEST (VFFPT)

The Geotek proposed testing procedures called for starting with the current steep angle seal sub and lip seal/o-ring combination. Since the current configured PCTB was deployed extensively during the land test and during horizontal full function bench testing prior to the land test, the decision was made by the UT/DoE representative not to repeat these tests and test only the modified configurations. Both the new 10° Bevel and Radiused Seal Subs were used during the VFFPT and the double lip seal was used as well as the full complement of PCTB III improvements were used in all the tests.

Note that for the VFFPT, only the autoclave, pressure section, and balancing actuation cylinder is used. The upper assembly is not used in these tests.

For all these tests the following nominal pressures were used.

Reservoir Pressure: 3,000 psi

Regulator Set (Boost) Pressure: 1,500 psi

Hydrostatic Pressure: 1,000 psi

Nine tests were conducted. A table of the results is in Appendix A. All tests except for three were completely successful. Two additional tests were partially successful and one failed. The following tests had problems.

Test 3 – The tool failed to fully stroke initially but finally fully stroked after several attempts to pull it using the actuation cylinder. The autoclave contained the fully boosted pressure and was ultimately successful. The maximum force applied by the actuator to the release rod was ~2,000 lbs. This force is well within the capabilities of a wireline unit in the field. Since the modified parts now prevent the PCTB from releasing from the BHA until it is fully stroked internally, should this particular hang up occurred in the field, the wireline operator would be able to work the wireline up and down and achieve the same results. In the event the PCTB fails to stroke in the field, it would be necessary to shear release pin in the pulling tool and pull it out of the hole. Then the emergency pulling tool, which engages only the PCTB upper latch, would have to be run in the hole to recover the PCTB. In this case the ball valve would likely remain open.

Upon disassembly, no definitive evidence was observed as to the cause of the hang up. However, one of the port covers was found to be slightly above flush with the OD of the tool and may have been the cause of the hang up.

Test 6 – This tool also failed to stroke but, this time repeated pulling did not free it. The tool was disassembled and it was discovered that the Disappearing Detent had not dropped into its groove. Some rough edges including a small lip on each tooth hadn't been deburred and this could have contributed to the problem. Detent was smoothed and replaced. However, this is considered an operator error. The assembler is supposed to rotate the inner assembly in an eccentric motion to check and make sure all of the Disappearing Detents are properly seated in their groove before final assembly. A trained operator can feel if a Disappearing Detent is not properly seated. This apparently was not properly done.

Test 7 – During this test the actuator was actuated and the PCTB only partially stroked. The actuator was worked up and down several times when both the annulus pressure and the autoclave pressure were observed to increase to ~1,125 psi and the PCTB could not be stroked further. The annular pressure was slowly bled off to zero as usual, simulating coming out of the hole on wireline. The autoclave held pressure but the pressure dropped from ~1,125 to ~1,070 psi and then remained there. The PCTB was rigged down for autopsy.

From visual observation of the pressure gauges, readouts and DST data, it appears the boost occurred before the autoclave was fully sealed, as indicated by both the annulus and the autoclave pressures increasing simultaneously while stroking the PCTB. Since the annular volume is connected to an accumulator during the test, the accumulator absorbed some of the boost pressure. Thus, only 125 psi was added to the system rather than the full 500 psi of the boost. This is indicated by a 1,175 psi spike in the autoclave pressure data before the system equalized at ~1,100 psi. Upon disassembly, the boost reservoir pressure was found to be below what is normally observed which would be consistent if the compensating piston in the pressure control section had travelled to the end of its chamber as it would if the boost pressure had escaped through an open ball.

As the annulus pressure was slowly bled off to simulate coming out of the hole, both the annulus pressure and autoclave pressure dropped together until the pressure reached ~1,025 psi at which point the autoclave pressure stopped dropping. This can happen if the ball valve closes too slowly and the boost from the pressure control section escapes. When there is no pressure boost or, if the pressure boost is lost, the ball moves upward to compensate for volume increase as the inner tube plug seal continues to move upward after ball valve closure. As the annular pressure is lowered coming out of the hole, the autoclave held the static pressure and did not necessarily leak. Similar response has been observed many times in the past both in the field and in lab tests when the boost pressure does not occur. The reason for the drop in pressure can be attributed to the ball moving back into the fully closed position as pressure is reduced which increases the autoclave volume and lowers the autoclave pressure until the ball is fully seated against the ball follower. It is unlikely but also possible that the ball did not close until some pressure had been bled off.

Upon disassembly of the ball valve, it was found to be closed in the normal position. The reset tool was installed to compress the ball valve spring for further disassembly. When the reset tool was removed, the seal carrier hung up inside the ball valve housing. A slight tap on the housing with a hammer freed the seal carrier and it slammed to the fully closed position driven by the compressed ball valve spring. The reset tool was installed again to compress the ball valve spring and again when the reset tool was removed the seal carrier hung up inside the ball valve housing. Further investigation revealed small raised areas at the top of the ball valve housing windows on the ID. These are caused by the ball moving too far upward and deforming the ID of the ball valve housing when the reset tool engaged and tightened too much. These dings prevent instantaneous travel of the seal carrier. The dings were ground off. Retesting using the ball resetting tool confirmed that the problem was fixed.

This again is considered operator error as the current procedure calls for the assembler to fire the ball several times during reassembly to verify correct operation. Seal carrier sticking or slow ball valve closure would have been observed and corrected had the assembler followed the procedure.

3.3. HORIZONTAL SPACE-OUT TEST

The Outer Core Barrel (OCB) was assembled and the 6-5/8 FH Modified connections were tightened as much as possible using a chain tong. The PCTB lower section was slid part way into the OCB using a fork lift. A lifting clamp was attached to the top of the lower section to keep it from sliding further, similar to how it is done in the field except for the PCTB being horizontal. The PCTB upper section was picked up and made up to the lower section horizontally. The lifting clamp was removed and the full PCTB assembly was slid into the OCB. Note, the running tool was not used since it would go too far inside the OCB to be released manually. Thus a piece of 4x4 lumber was used to drive the PCTB assembly into the OCB.

The PCTB stopped sliding about 12” above the landing point when the outer latch dogs contacted the head sub ID. Note, normally the outer latch dogs are retracted by the weight of the PCTB hanging on the running tool. The PCTB was pulled out of the OCB until the outer latch dogs were accessible. The running tool was installed in the PCTB to retract the outer latch dogs. A spare latch sleeve was slid over the outer latch dogs to keep them retracted. The running tool was manually released and removed. The PCTB was then slid back into the OCB as far as it would go while removing the spare latch sleeve once the outer latch dogs had entered the head sub ID.

It appeared that the PCTB was within 1/4" - 1/2" of latching but had not latched. To confirm that the PCTB was not latched, a sledge hammer was used to bump the PCTB out of the OCB by hammering on the cutting shoe. The PCTB continued to slide out of the OCB confirming that it was not latched.

Figure 5: Horizontal space-out test. A) The bottom hole assembly viewed from the bottom. B) The PCTB inserted into the head and top sub. C) The face bit with cutting shoe fully inserted.

The assemblies were double checked and found to be OK. The head sub was removed from the OCB to verify that the latch sleeve had not come lose and backed off. Note, removing the head sub allowed the outer latch dogs to expand inside the OCB and they cannot be retracted without engaging the pulling tool. The latch sleeve was found to be tight and the length verified to be correct. The head sub was made up to the OCB again and shouldered against the top sub. Since the outer latch dogs were locked in the expanded configuration and could not pass through the latch sleeve ID when the head sub was made up, the PCTB had to be latched in place. To verify the PCTB was latched into the OCB the cutting shoe was once again bumped with a sledge hammer and the PCTB would not move, indicating the PCTB was latched into the OCB.

The overall space out was checked and found to be correct. Thus, when the PCTB is made up with the new modified parts it will latch into the normal/standard PCTB BHA in the field.

The pulling tool was then inserted into the PCTB. A strap was connected between the pulling tool and the fork lift. The fork lift was used to pull the PCTB out of the OCB. Closing of the ball valve could be heard as the PCTB was stroked internally while pulling the PCTB out of the OCB. This further verified that the space out was correct and the internal stroking of the PCTB was occurring in the proper sequence.

The PCTB was removed from the OCB and disassembled. The OCB was then disassembled, ending the testing program.

Discussion:
The failure of the PCTB to latch on the first attempt was due to friction caused by performing the test horizontally. When the head sub was made up the second time, the latch sleeve was able to push against the outer latch dogs more evenly and with the power screw effect of the thread the PCTB was seated properly. This type of failure to latch is not likely to occur in the field where everything is done vertically.

3.4. FLOW TEST

The PCTB III upgrade parts, Fugro PCTB retrofit parts and instrumented core liner were completed on time and shipped to China for the planned flow test on the Fugro pressure coring operation. Unfortunately, customs delays in China and operations on board the drill ship prevented the Flow Test from being carried out.

It is recommended that this test be completed during the Marine Trial or sooner if another opportunity presents itself.

4. CONCLUSIONS AND RECOMMENDATIONS

- PCTB III tool improvements assemble and function properly.
- The double lip seal (PolyPak) autoclave inner tube plug seal configuration should be deployed in the future.
- The 10° Bevel Seal Sub should be deployed in the future.
- The PCTB space out, when configured with the new and modified parts, is compatible with the current PCTB BHA.
- The PCTB functioned quite well during the tests showing no signs of delayed boost and trapping the boost pressure during all of the tests but one.

APPENDICES

A. Seal Sub Test Data Sheet
B. Vertical Full Function Pressure Test Results Summary
C. Vertical Full Function Pressure Test Pressure Charts

Appendix A, Seal Sub Seal Test Data Sheet

Seal Sub Test

UT/DOE Lab Testing 2016 - SOW Phase 2, Subtask 4.2

Parameters: Pressure used to actuate the tool.
Piston Area: 0.69 in²
Starting Displacement: -2.0
Tare/Equilibrium (psi): 180

Test #	Time	Displacement	Pressure at Seal Entry	Net Pressure	lb-f	Comments
1	13:51	109	383	203	140	35° Original Seal Sub with O-Ring
2	13:52	121	386	206	142	
3	13:54	125	361	181	125	
4	13:55	129	382	202	139	
5	13:56	137	395	215	148	
6	13:57	135	368	188	130	
7	13:57	132	359	179	124	
8	14:05	140	367	187	129	
9	14:07	134	367	187	129	
10	14:09	136	359	179	124	
AVG					133	
11	14:25	92	312	132	91	35° Original Seal Sub with Polypak
12	14:26	90	298	118	81	
13	14:30	98	295	115	79	
14	14:31	96	285	105	72	
15	14:32	96	281	101	70	
16	14:35	97	300	120	83	
17	14:36	97	297	117	81	
18	14:37	97	300	120	83	
19	14:38	96	296	116	80	
20	14:39	96	287	107	74	
AVG					79	
21	14:51	191	287	107	74	Radiused Seal Sub, Polypak
22	14:56	201	278	98	68	
23	15:00	196	270	90	62	
24	15:01	203	273	93	64	
25	15:04	209	271	91	63	
26	15:04	199	278	98	68	
27	15:05	198	261	81	56	
28	15:10	215	259	79	55	
29	15:14	207	263	83	57	
30	15:23	207	268	88	61	
AVG					63	

Seal Sub Test

UT/DOE Lab Testing 2016 - SOW Phase 2, Subtask 4.2

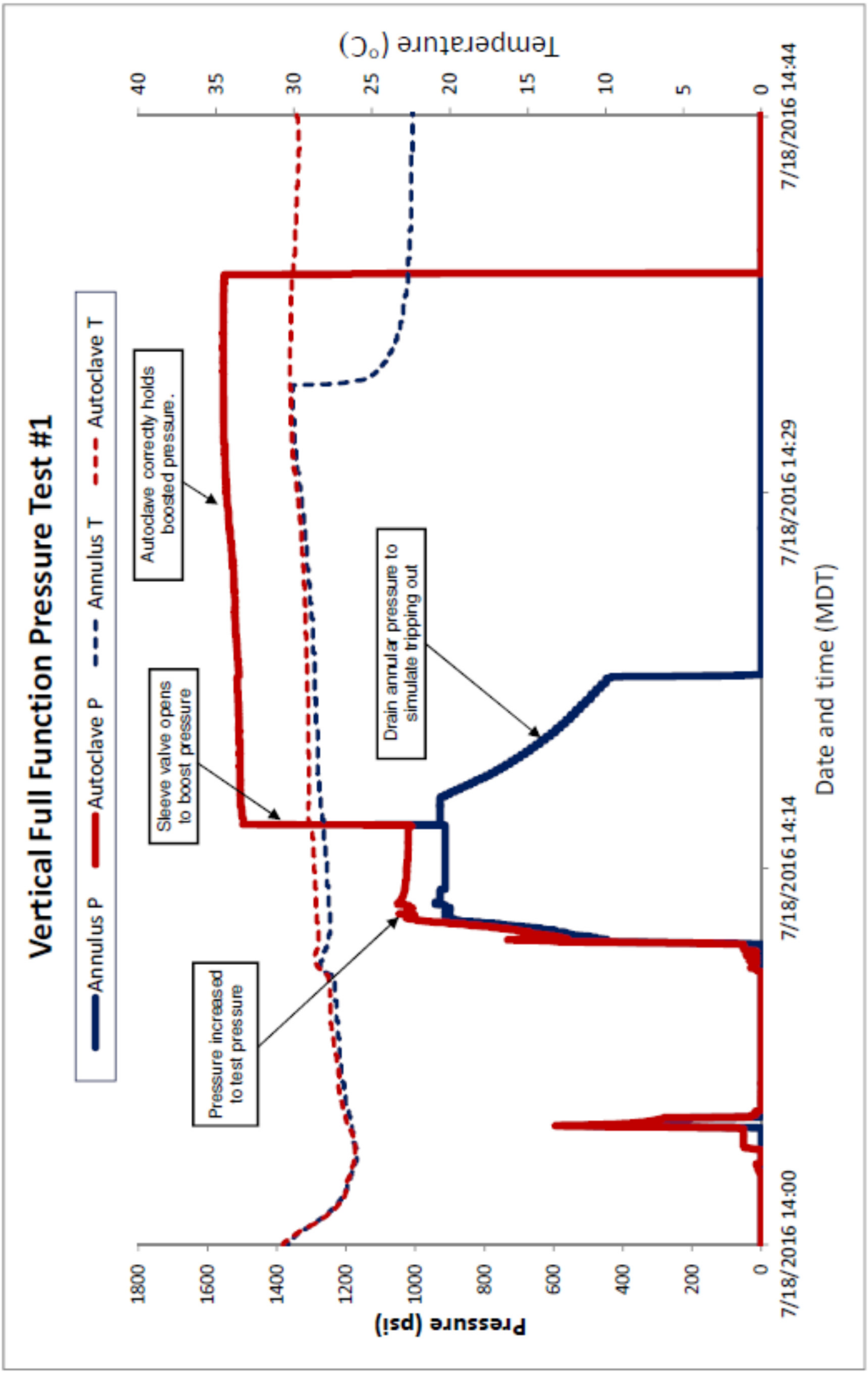
Parameters: Pressure used to actuate the tool.
Piston Area: 0.69 in²
Starting Displacement: -2.0
Tare/Equilibrium (psi): 180

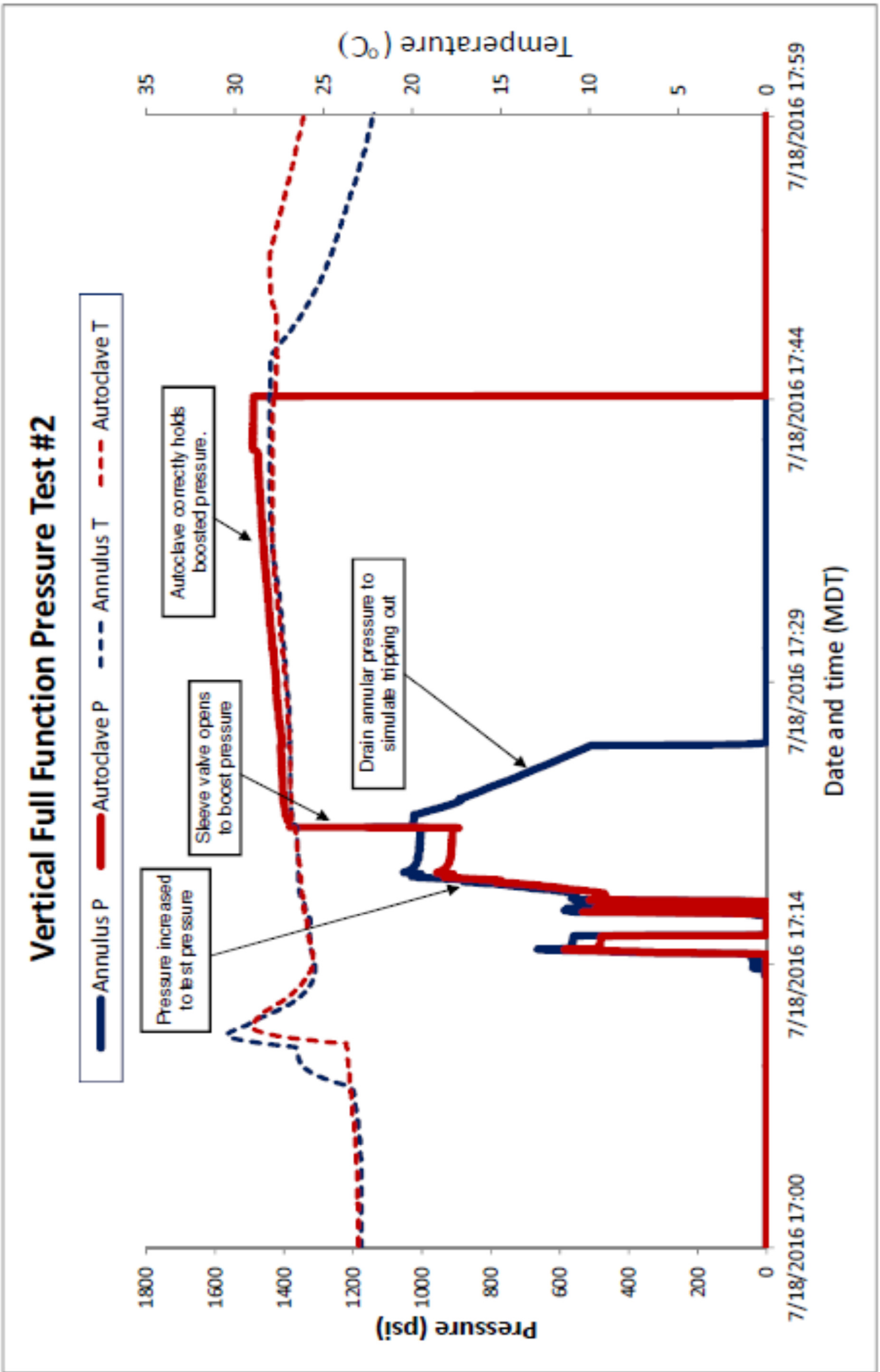
Test #	Time	Displacement	Pressure at Seal Entry	Net Pressure	lb-f	Comments
31	15:27	195	268	88	61	Radiused Seal Sub, O-Ring
32	15:28	206	256	76	52	
33	15:30	198	268	88	61	
34	15:32	208	264	84	58	
35	15:34	203	261	81	56	
36	15:35	196	263	83	57	
37	15:36	199	253	73	50	
38	15:38	196	262	82	57	
39	15:39	198	257	77	53	
40	15:41	198	249	69	48	
AVG					55	
41	15:57	28	224	44	30	10° Beveled Seal Sub, O-Ring
42	16:00	28	210	30	21	
43	16:01	48	219	39	27	
44	16:05	40	207	27	19	
45	16:06	35	212	32	22	
46	16:09	39	193	13	9	
47	16:10	35	193	13	9	
48	16:11	41	213	33	23	
49	16:13	41	204	24	17	
50	16:15	42	207	27	19	
AVG					19	
51	16:17	29	215	35	24	10° Beveled Seal Sub, Polypak
52	16:19	27	216	36	25	
53	16:21	25	214	34	23	
54	16:23	25	204	24	17	
55	16:24	26	205	25	17	
56	16:25	24	201	21	14	
57	16:27	25	209	29	20	
58	16:28	21	197	17	12	
59	16:29	24	195	15	10	
60	16:29	27	191	11	8	

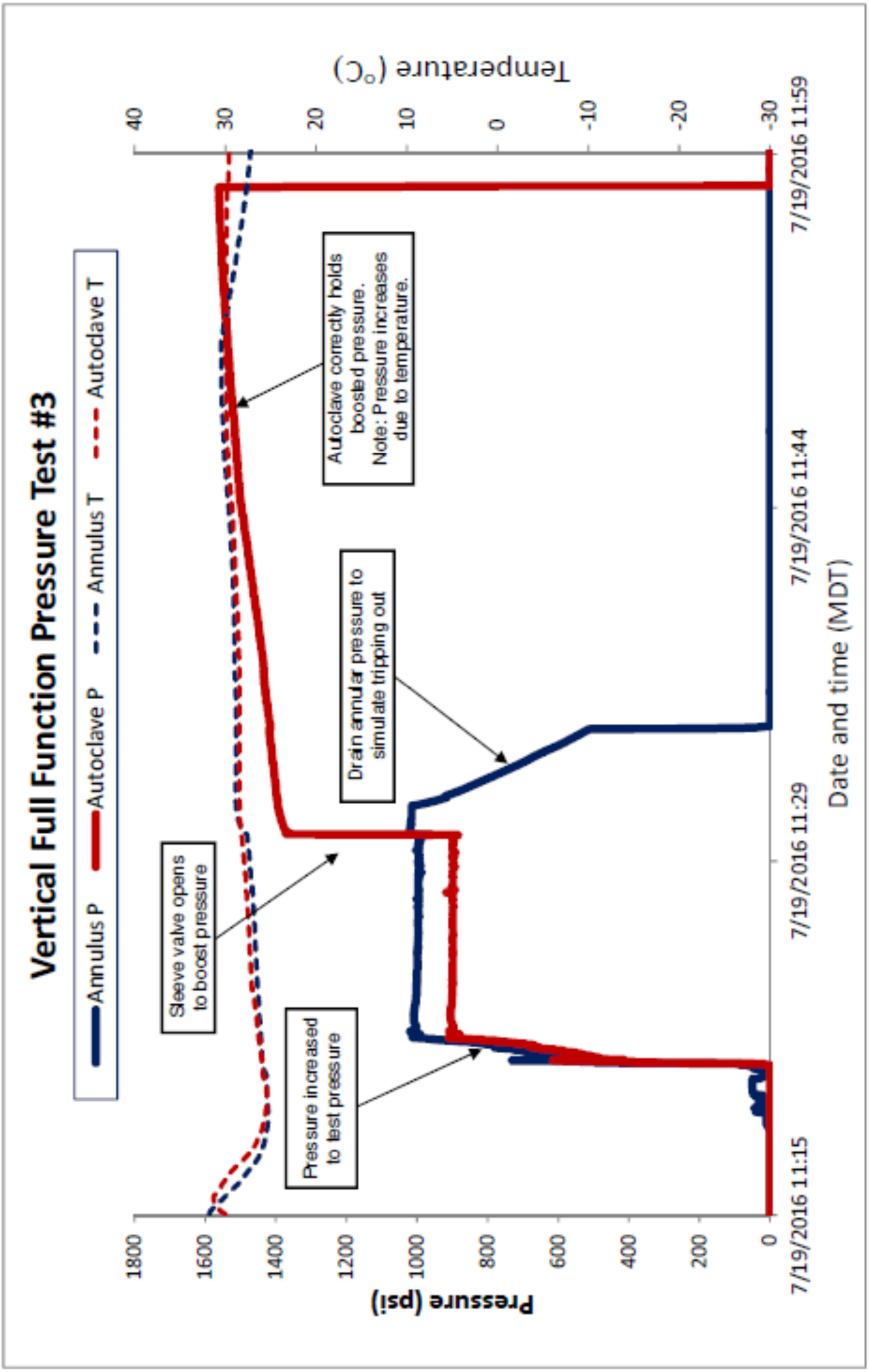
Appendix B, Vertical Full Function Pressure Test Summary Sheet

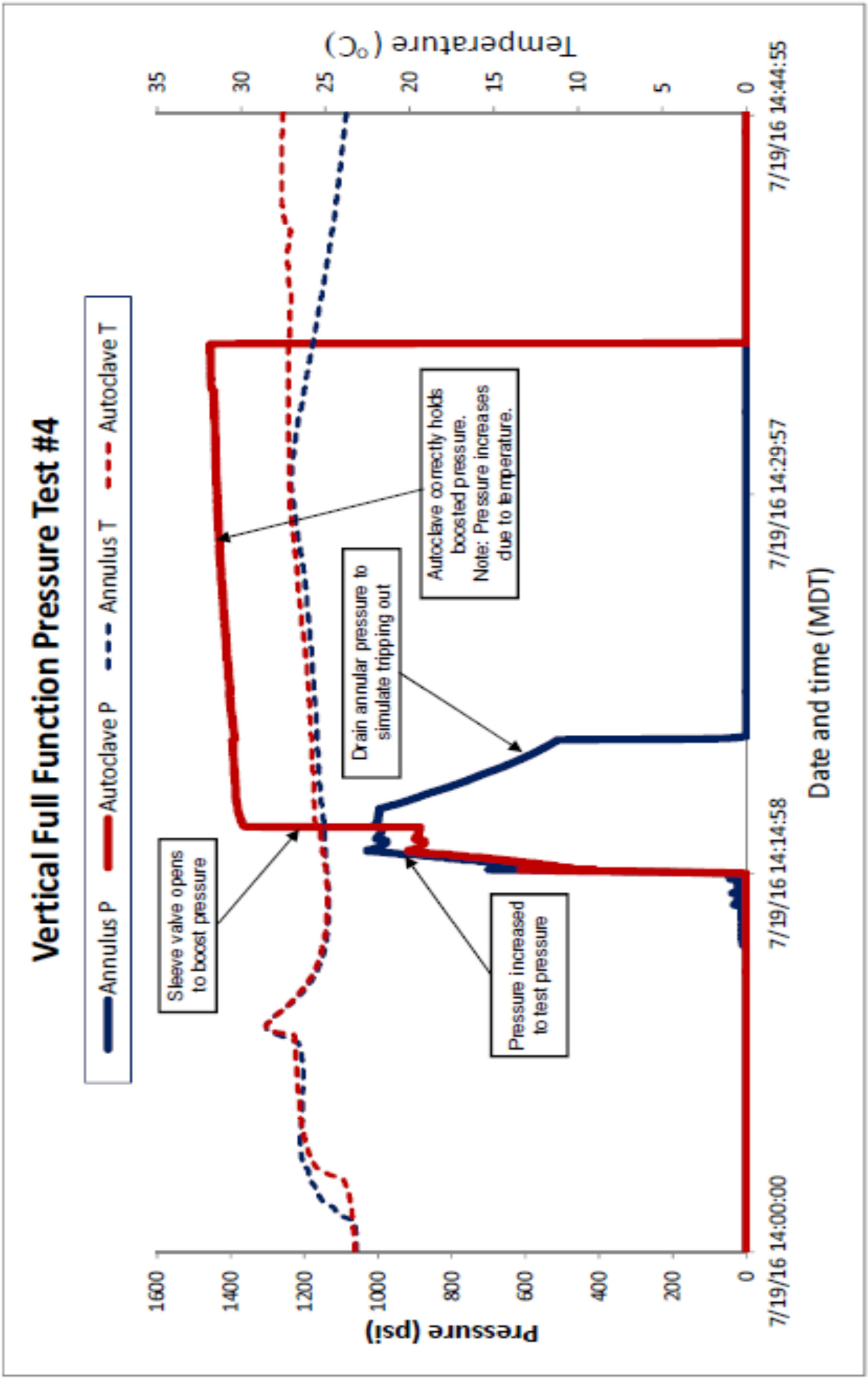
Test Attempt	Test No.	Date	Seal Sub Type (B) 10° Bevel (R) Radius	DST Autoclave	DST Annulus	Reservoir Pressure	Set Pressure	Annulus Before Closure	Annulus After Closure	Autoclave Pressure After Closure	Autoclave Pressure after POOH	Sleeve Valve Travel	Comment
				Run No.	Run No.	psi	psi	psi	psi	psi	psi	in	
1		7/18/2016	B	23C7068	20C7066	3049	1520	1000	1025	1497	1550	0.43	Good test.
2		7/18/2016	B	21C7066	24C7068	3006	1510	1006	1011	1400	1525		Good test.
3		7/19/2016	B	22C7066	25C7068	3009	1515	1000	1008	1383	1562	0.43	Jammed on first pull. Pulled and released 10-15 times and it came free. Good test after that. No definitive reason for the jamming was identified during disassembly.
4		7/19/2016	B	24C7066	26C7068	3030	1512	1284	1284	1383	1457	0.43	Good test.
5		7/19/2016	R	25C7066	27C7068	3015	1506	913	928	1498	1553	0.47	Good test.
6		7/20/2016	R	26C7066	28C7068	3040	1508	1000	NA	NA	NA	0.47	Moved 3/4" and stopped. Pulled a few times and decided to disassemble and inspect. Found one collapsing detent was not in its groove but pinched between the IT Release Sleeve and the Lower IT Plug.
7		7/20/2016	R	29C7068	27C7066	3010	1510	1000	1125	1125	1070	0.46	Boost occurred before the ball valve was completely closed. This pressured up the annulus as well during the pressure boost. However, the ball valve sealed during depressurization indicating it has closed late. Burrs were discovered on the ball valve housing causing the seal carrier to hang up delaying ball valve closure.
8		7/21/2016	R	28C7066	30C7068	3005	1501	990	1010	1375	1410	0.46	Good test.
9		7/21/2016	R	28C7066	30C7068	3004	1512	990		1470	1490		Good test. However, the annulus DST migrated from the annulus chamber below the ball into the autoclave and also recorded the autoclave pressure. As a result, no annular pressures were recorded.

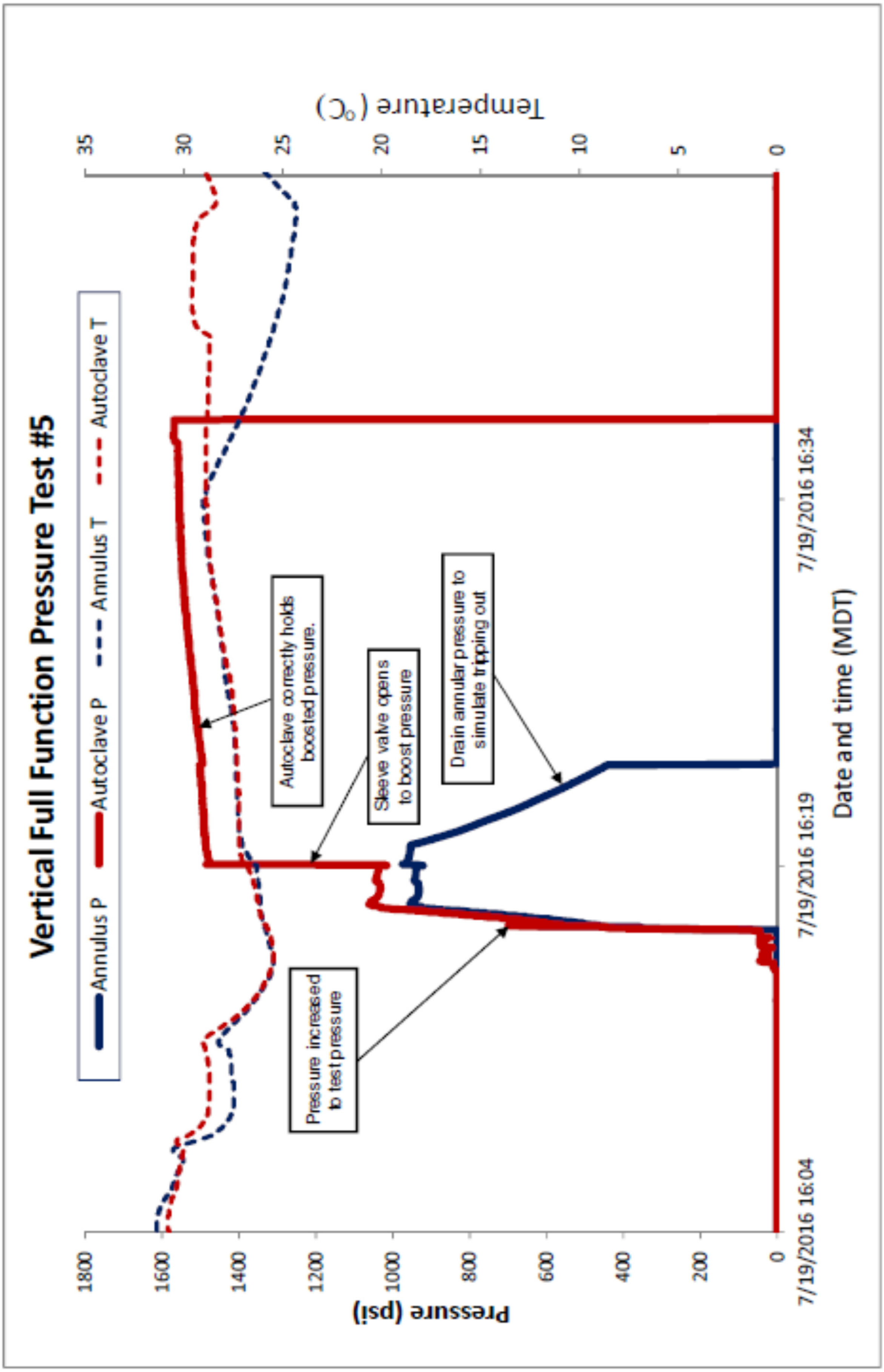
Appendix C, Vertical Full Function Pressure Test Pressure Charts



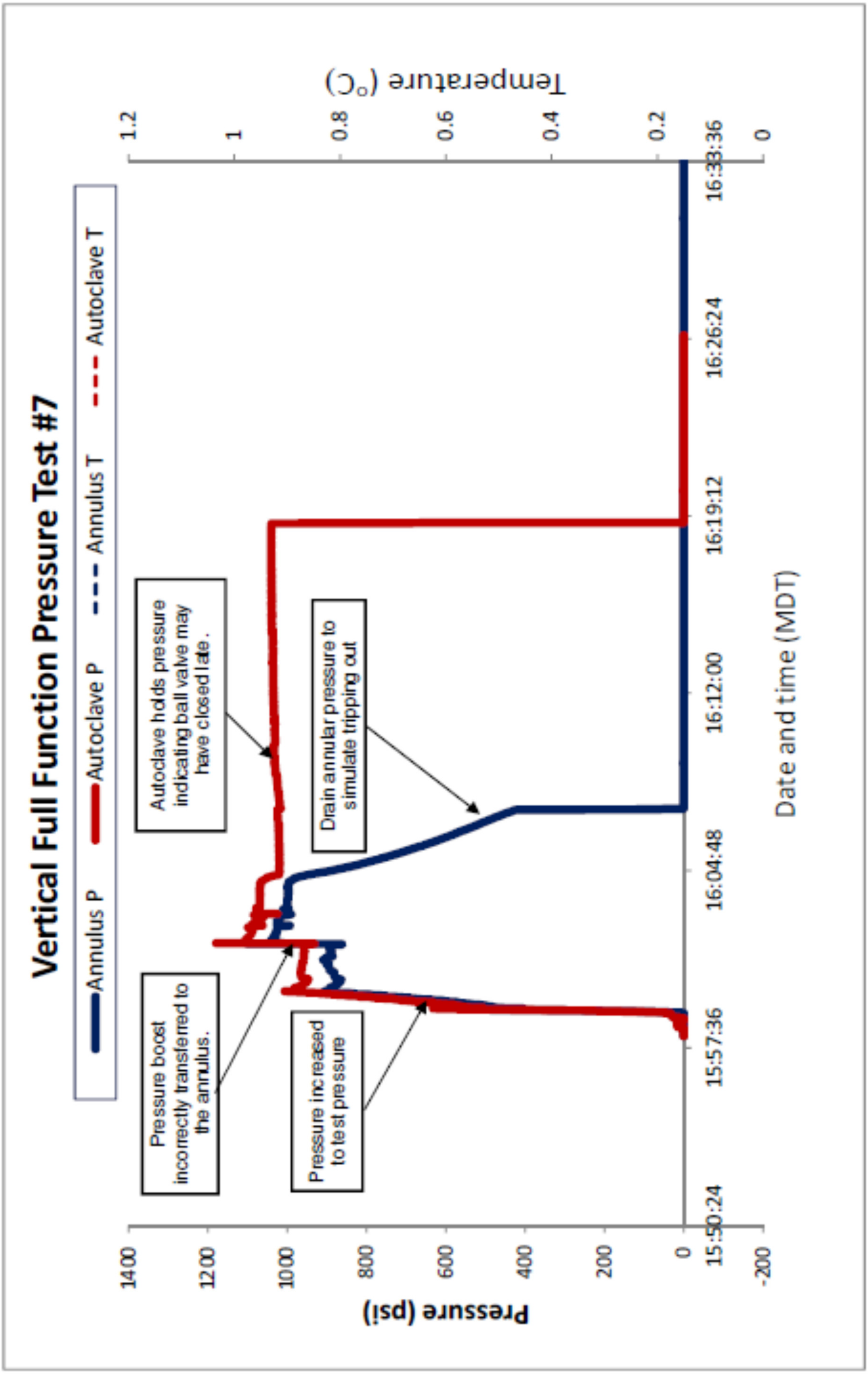

Vertical Full Function Pressure Test #2
Annulus P
Autoclave P
Annulus T
Autoclave T
Pressure increased to test pressure
Sleeve valve opens to boost pressure
Drain annular pressure to simulate tripping out
Autoclave correctly holds boosted pressure.
Pressure (psi)
Temperature (°C)
Date and time (MDT)
7/18/2016 17:00
7/18/2016 17:14
7/18/2016 17:29
7/18/2016 17:44
7/18/2016 17:59
0
200
400
600
800
1000
1200
1400
1600
1800
0
5
10
15
20
25
30
35


Vertical Full Function Pressure Test #3
Annulus P
Autoclave P
Annulus T
Autoclave T
Pressure (psi)
Temperature (°C)
Date and time (MDT)
7/19/2016 11:15
7/19/2016 11:29
7/19/2016 11:44
7/19/2016 11:59
Pressure increased to test pressure
Sleeve valve opens to boost pressure
Drain annular pressure to simulate tripping out
Autoclave correctly holds boosted pressure. Note: Pressure increases due to temperature.

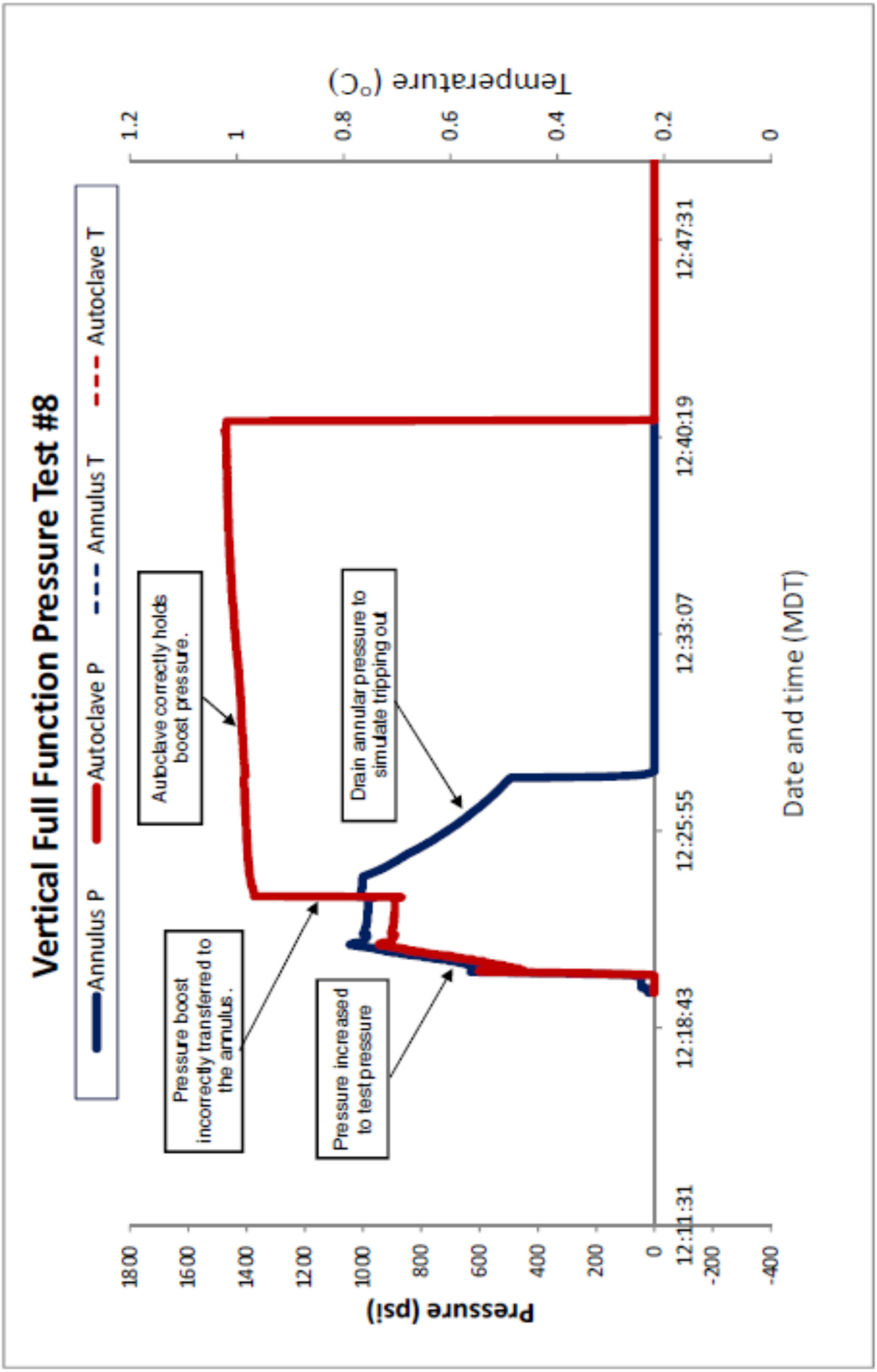

Vertical Full Function Pressure Test #4
Annulus P
Autoclave P
Annulus T
Autoclave T
Pressure (psi)
1600
1400
1200
1000
800
600
400
200
0
Temperature (°C)
35
30
25
20
15
10
5
0
Date and time (MDT)
7/19/16 14:00:00
7/19/16 14:14:58
7/19/16 14:29:57
7/19/16 14:44:55
Sleeve valve opens to boost pressure
Pressure increased to test pressure
Drain annular pressure to simulate tripping out
Autoclave correctly holds boosted pressure. Note: Pressure increases due to temperature.

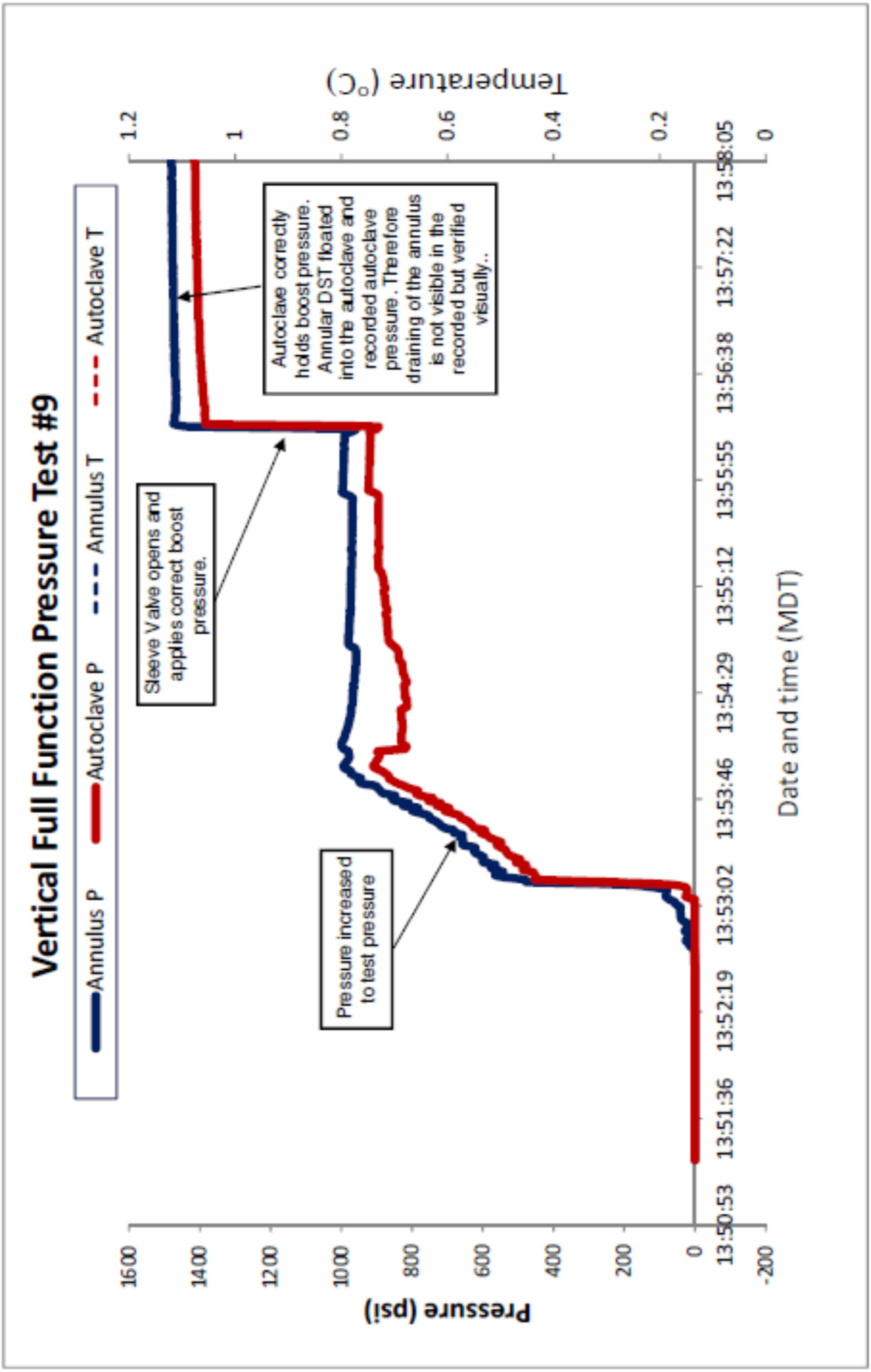


Vertical Full Function Pressure Test #5
Annulus P
Autoclave P
Annulus T
Autoclave T
Pressure (psi)
Temperature (°C)
Date and time (MDT)
7/19/2016 16:04
7/19/2016 16:19
7/19/2016 16:34
Pressure increased to test pressure
Sleeve valve opens to boost pressure
Autoclave correctly holds boosted pressure.
Drain annular pressure to simulate tripping out



Vertical Full Function Pressure Test #7
Annulus P
Autoclave P
Annulus T
Autoclave T
Autoclave holds pressure indicating ball valve may have closed late.
Drain annular pressure to simulate tripping out
Pressure boost incorrectly transferred to the annulus.
Pressure increased to test pressure
Pressure (psi)
1400
1200
1000
800
600
400
200
0
-200
Temperature (°C)
1.2
1
0.8
0.6
0.4
0.2
0
15:50:24
15:57:36
16:04:48
16:12:00
16:19:12
16:26:24
16:33:36
Date and time (MDT)


Vertical Full Function Pressure Test #8
Annulus P
Autoclave P
Annulus T
Autoclave T
Autoclave correctly holds boost pressure.
Drain annular pressure to simulate tripping out
Pressure boost incorrectly transferred to the annulus.
Pressure increased to test pressure
Pressure (psi)
Temperature (°C)
Date and time (MDT)
1800
1600
1400
1200
1000
800
600
400
200
0
-200
-400
1.2
1
0.8
0.6
0.4
0.2
0
12:11:31
12:18:43
12:25:55
12:33:07
12:40:19
12:47:31



Vertical Full Function Pressure Test #9
Annulus P
Autoclave P
Annulus T
Autoclave T
Pressure (psi)
Temperature (°C)
Date and time (MDT)
-200
0
200
400
600
800
1000
1200
1400
1600
0
0.2
0.4
0.6
0.8
1
1.2
13:50:53
13:51:36
13:52:19
13:53:02
13:53:46
13:54:29
13:55:12
13:55:55
13:56:38
13:57:22
13:58:05
Pressure increased to test pressure
Sleeve Valve opens and applies correct boost pressure.
Autoclave correctly holds boost pressure. Annular DST floated into the autoclave and recorded autoclave pressure. Therefore draining of the annulus is not visible in the recorded but verified visually..