

FAST-1.2.2 User Installation and Verification Guide

Developed Under NQA-1-2017

July 2026

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Pacific Northwest National Laboratory
Richland, Washington 99354

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Project No.	83915 Task 31310024S022
Product Management Office No. / Organization	PM053/ Nuclear Science and Legacy Waste

Approvals

Role	Name	Signature	Date
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Lead Software Developer	Ken Geelhood	Kenneth J (Ken) Geelhood 	Digitally signed by Kenneth J (Ken) Geelhood Date: 2026.07.15 09:35:53 -07'00'
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Revision History

Revision	Date	Comments
0	July 2026	Initial Release

Introduction

The purpose of this document is to provide the user information about the installation of Fuel Analysis for Steady state and Transient (FAST)-1.2.2 on their computers or servers. General information about the code and supported operating systems is described in Section 1.0. Self-service oriented FAST-1.2.2 software licensing steps are described in Section 2.0. An installation verification test suite is provided with FAST-1.2.2 and described in Section 3.0. A convenience script for converting Fuel Rod Analysis Program – Constant (FRAPCON) to FAST inputs is discussed in Section 4.0.

FAST-1.2.2 was developed and released under a software quality assurance program based upon NQA-1-2017 at Pacific Northwest National Laboratory (PNNL). FAST-1.2.2 is the latest baseline code. The installation verification test suite contains both steady state and transient Anticipated Operation Occurrences (AOOs), accident conditions, such as Reactivity Initiated Accidents (RIAs) and Loss of Coolant Accidents (LOCAs).

Acronyms and Abbreviations

AOO	Anticipated Operational Occurrences
ASME	American Society of Mechanical Engineers
FAST	Fuel Analysis for Steady state and Transient
FGR	Fission Gas Release
FRAPCON	Fuel Rod Analysis Program – CONstant
hash	Hash Function used to map data of an arbitrary size to fixed-size values.
LOCA	Loss of Coolant Accident
LWR	Light Water Reactor
NRC	United States Nuclear Regulatory Commission
NQA-1	Nuclear Quality Assurance – 1
MD5	Widely used 128-bit message-digest hash value for uniquely identifying files.
PNNL	Pacific Northwest National Laboratory
POC	Point of Contact
QA	Quality Assurance
QAP	Quality Assurance Plan
RIA	Reactivity Initiated Accident
SHA-1	Widely used 160-bit message-digest hash value for uniquely identifying files.

Definitions

This Section provides definitions specific to the software project.

Assessment	A review, evaluation, inspection, test, check, surveillance, or audit to determine and document whether items, processes, systems, or services meet specified requirements and perform effectively. (NQA-1-2017)
Acceptance Testing	The process of exercising or evaluating a system or system component by manual or automated means to ensure that it satisfies the specific requirements and to identify differences between expected and actual results in the operating environment. (NQA-1-2017)
Configuration Item	A collection of hardware or software elements treated as unit for the purpose of configuration control. (NQA-1-2017)
Configuration Management (software)	The process of identifying and defining the configuration items in a system (i.e. software and hardware), controlling the release and change of those items throughout the system's life cycle, and recording and reporting the status of configuration items and change requests. (NQA-1-2017)
Baseline	A specification or product that has been formally reviewed and agreed upon, that thereafter serves as the basis for use and further development, and that can be changed only by using an approved control process. (NQA-1-2017)
Error	A condition deviating from an established baseline, including deviations from the current approved computer program and its baseline requirements. (NQA-1-2017)
Confluence	Confluence is an easy-to-use web-based tool that is utilized for electronically documenting software in a wiki format. Documents can also be controlled. It offers the ability to document, collaborate, and share.
Graded Approach	The process of ensuring that the level of analysis, documentation, and actions used to comply with a requirement is commensurate with: - the relative importance to safety, safeguards, and security - the magnitude of any hazard involved - the life-cycle stage of a facility or item - the programmatic mission of a facility - the particular characteristics of a facility or item - the relative importance of radiological and nonradiological hazards - any other relevant factors (NQA-1-2017)
HDI	A web search engine that houses PNNL's Lab-level requirements and procedures and considerations for conducting work. The content is delivered via graphical workflows (step-by-step flowcharts with steps for each activity), through narrative work controls (listing of requirements and considerations for managing specific risks and hazards), or in forms or exhibits (linked documents that include greater detail).
Independent	(Independent Reviews or Independent Testing) Person sufficiently independent with respect to the material/product they are reviewing/testing; they did not perform the work they are reviewing or testing. Staff also possess enough subject matter expertise to adequately review/test/evaluate.
Operating Environment	A collection of software, firmware, and hardware elements that provide for the execution of computer programs. (NQA-1-2017)

Software Design Verification	The process of determining if the product of the software design activity fulfills the software design requirements. (NQA-1-2017)
Software Engineering	(a) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software. (b) The study of approaches in (a) (NQA-1-2017)
Test Case	A set of test inputs, execution conditions, and expected results developed for a particular objective, such as to exercise a particular program path or to verify compliance with a specific requirement. (NQA-1-2017)
Test Plan (Procedure)	A document that describes the approach to be followed for testing a system or component. Typical contents identify items to be tested, tasks to be performed, and responsibilities for the testing activities. (NQA-1-2017)
Verification	Mathematical proof of the correctness of algorithms, by confirming that code subroutines and functions produce the expected numerical output.
Validation	The process of evaluating software to determine whether it satisfies specified requirements, by comparing code predictions to experimental data.
Unit test	Process or code developed to test the numeric accuracy and functionality of new or modified subroutines and functions.
Unit test suite	Set of unit tests created while developing and maintaining FAST.
Verification test suite	Set of input files that exercise all the code options, used to verify that code changes do not negatively impact code performance, and that results are as expected.
Validation test suite	Set of input files used to validate the codes' predictions against experimental measurements, to quantify the accuracy, bias, and uncertainty of code predictions.

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1.0 General Software Information

FAST-1.2.2 has been compiled on Windows 11 and Red Hat Enterprise Linux 9.4 operating systems. The compiled executables in Table 1 were then tested on Windows and Linux operating systems listed in Table 2 using the test suites available in Section 3.0. FAST is not currently supported on MacOS.

Table 1 – FAST-1.2.2 Executable Identification

Executable	OS	Hash
FAST-1.2.2.exe	Windows	MD5 7f6743791d8098d758cc53a47b9460eb SHA-1 68a62ca44967185ed95e6cb9764fe62c7cf7a781
FAST-1.2.2	Linux	MD5 874e55718010579f22290090391cf6e5 SHA1 7ccddda063affa17b7c5b8a7a3be5dee1f6971e9

Due to the large variety of operating systems available to our users' group, not all possibilities can be tested. The list in Table 2 is an attempt to provide wide coverage of currently supported systems: Windows and Linux. If your installation on a current operating system not listed below results in larger than expected differences or difficulties, please contact PNNL (see website contact information) and we will attempt to identify and correct/mitigate the issue. The list in Table 2 below is comprehensive enough that unforeseen difficulties with installation should be rare.

Table 2 – FAST-1.2.2 Tested Operating Systems

Operating System	Version	Comments
Windows 11 Enterprise	25H2	OS Build 26200.8655
Windows Server Standard 2025	24H2	OS Build 26100.32995
Debian Trixie	13.5	Linux Kernel 6.12.90+deb13.1-amd64
Linux Mint Zena	22.3	Linux Kernel 6.17.0-35-generic
openSUSE Leap	16.0	Linux Kernel 6.12.0-160000.35-default
Ubuntu Desktop	26.04	Linux Kernel 7.0.0-27-generic
Red Hat Enterprise Linux	9.4	Linux Kernel 5.14.0-427.26.1.el9_4.x86_64

1.1 Acquiring the Software

The FAST website is <https://fast.labworks.org>. The website contains limited information for visitors not logged in but more documentation and access to the software for logged in visitors. Visitors without log in credentials may apply using the “Join Us” tab on the homepage.

The Codes tab on the homepage lists the codes available for download, FAST-1.2.2, FAST-1.2.1 FRAPCON-4.0 and FRAPTRAN-2.0. This document will focus on FAST-1.2.2. Follow the link to FAST-1.2.2 and download the zip or tgz file that is applicable to your target machine’s file decompression software. Typically, Windows users would choose the zip file while Linux users can decompress either zip or tgz files with preinstalled software. MacOS is not currently supported.

The following hash values are associated with the zip and tgz files along with the text file listing of the contents. The zip and tgz files contain identical contents.

Table 3 – FAST-1.2.2 File Identification

File	OS	Hash
FAST-1.2.2.zip	Windows/Linux	MD5 490765ea148333f3abddf49fee690164 SHA-1 fe2f997d3fad0d7c49ff4441499d723281a306cb
FAST-1.2.2.tgz	Windows/Linux	MD5 7e19aad40f01381548340436a52cc58e SHA1 1cedee16a3fdceeab9eb6a32f0ffa6cd32c36838
md5sum_listing	Windows/Linux	MD5 17b7775222ef318efeea3d8f76e7b191 SHA1 108c4ccd2231ac6e873ef86f8e006965881e549f
sha1sum_listing	Windows/Linux	MD5 8412dd498a680b3edfc5870b625b8ea9 SHA1 d3d70615b8f8b8fb6f02432525f3da60f95dc00a

The Linux command `tar -xzf FAST-1.2.2.tgz` will decompress the folder. The FAST-1.2.2.zip and FAST-1.2.2.tgz files have the same contents described in Table 4 below:

Table 4 – FAST-1.2.2 File Identification

Folder	Description
Convenience_Scripts	Python 3 conversion script, AIG, FRAPlot (See Section 4.0)
Installation_Verification	Installation Verification Tests (See Section 3.0)
Linux_Executable	Linux Executable
Linux_FAST_Licensing	Linux Licensing software (See Section 2.0)
Windows_Executable	Windows Executable
Windows_FAST_Licensing	Windows Licensing software (See Section 2.0)

These next steps are primarily for users needing to establish traceability from the identification in Table 1 and 3 above to the final installation location on their machines. These steps may also be used to verify that the executable file was not corrupted during the download and/or transfer process to the final location.

Once the executable and associated files are installed on your target machine, the SHA-1 or MD5 should be checked and compared to Table 1 and Table 3. Other, more secure, hashing algorithms are available such as SHA-2 however it is assumed that MD5 and/or SHA-1 will provide the user confidence the executable was not altered in the download/transfer process. Users that require hashes such as SHA-2 are encouraged to contact PNNL through the website.

Windows offers a pre-installed utility CertUtil and a downloadable utility FCIV available on the support.microsoft.com website. The pre-installed utility will be demonstrated here. Open a command prompt and navigate to the location of your executable or provide the path of the executable. Then execute the command: `CertUtil -hashfile FAST-1.2.2.exe SHA1` (or MD5 in place of SHA1) as shown in Figure 1:

```
E:\VirtualBox_Shared_E\FAST_Testing\FAST-1.2.2\FAST-1.2.2\Windows_Executable>CertUtil -hashfile FAST-1.2.2.exe md5
MD5 hash of FAST-1.2.2.exe:
7f6743791d8098d758cc53a47b9460eb
CertUtil: -hashfile command completed successfully.

E:\VirtualBox_Shared_E\FAST_Testing\FAST-1.2.2\FAST-1.2.2\Windows_Executable>CertUtil -hashfile FAST-1.2.2.exe sha1
SHA1 hash of FAST-1.2.2.exe:
68a62ca44967185ed95e6cb9764fe62c7cf7a781
CertUtil: -hashfile command completed successfully.
```

Figure 1: Window's CertUtil Hashing Example

Linux offers md5sum and sha1sum command line utilities as demonstrated in Figure 2 below:

```
cola105@WE50399 MINGW64 /E/VirtualBox_Shared_E/FAST_Testing/FAST-1.2.2/FAST-1.2.2/Linux_Executable
$ md5sum FAST-1.2.2
874e55718010579f22290090391cf6e5 *FAST-1.2.2

cola105@WE50399 MINGW64 /E/VirtualBox_Shared_E/FAST_Testing/FAST-1.2.2/FAST-1.2.2/Linux_Executable
$ sha1sum FAST-1.2.2
7ccddda063affa17b7c5b8a7a3be5dee1f6971e9 *FAST-1.2.2
```

Figure 2: Linux md5sum and sha1sum Example

A matching md5 or sha1 hash provides a very high likelihood that the executables were not corrupted during the download and transfer to the final location on the target machine. If the hashes do not match, try downloading FAST from the website again. Changes to the files change the hash values.

The location of the FAST executable on your target machine depends largely on preferences and your organizations rules or guidelines. The installation verification that is described in Section 3.0 can be performed on your target machine by updating the associated python script.

Linux users may have to install intel oneAPI runtime libraries via the instructions provided in Section 3.2. The user will encounter errors for missing libraries if they are not linked. It is recommended that the sourcing command be added to the user's path, either through the user's profile, or on machines with multiple users, this may be done on the system profile which flows down to the individual user's profiles.

2.0 Self-Service Licensing

Installations of FRAPCON 4.0 and FRAPTRAN 2.0 do not require these licensing steps.

A successfully copied FAST-1.2.2 executable in the target location of the target computer must now be licensed for it to operate. Licensing has been set up as self-service through the FAST website <https://fast.labworks.org> and the page https://fast.labworks.org/fast_license. Figure 3 below shows the website after clicking the “Codes” tab highlighted in a red box.

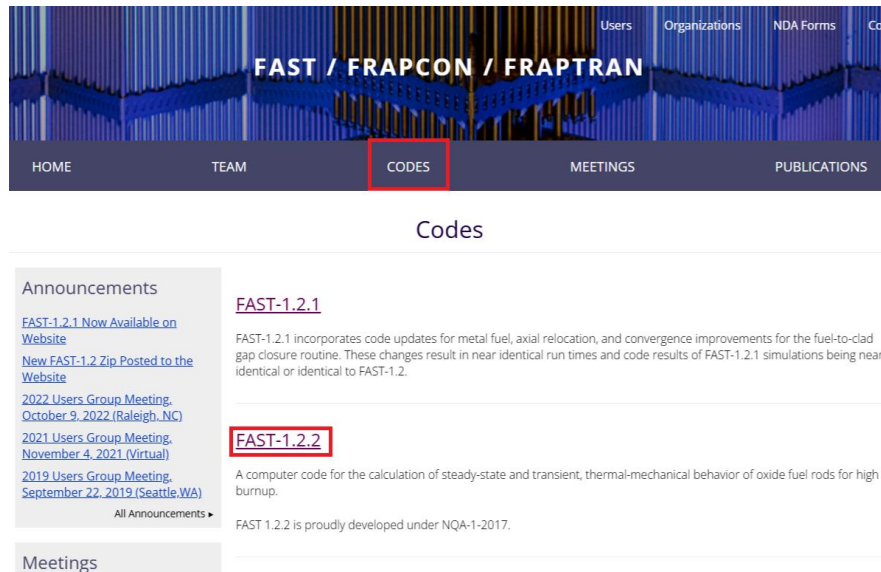


Figure 3: FAST Website FAST-1.2.2 Link Location

The link “FAST-1.2.2” in Figure 3 above will take you to the FAST-1.2.2 screen in Figure 4 below.

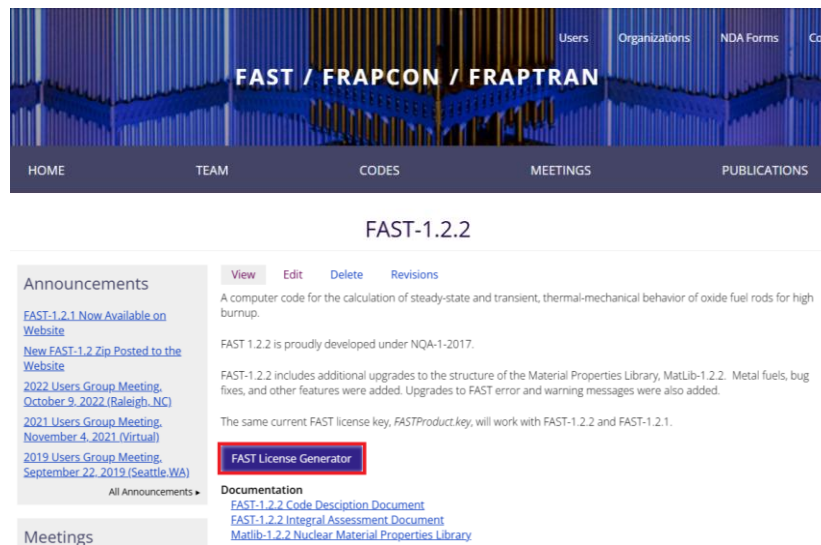


Figure 4: FAST Website Licensing Link Location

The link “FAST License Generation” in Figure 4 above will take you to the FAST License Generator screen in Figure 5 below.

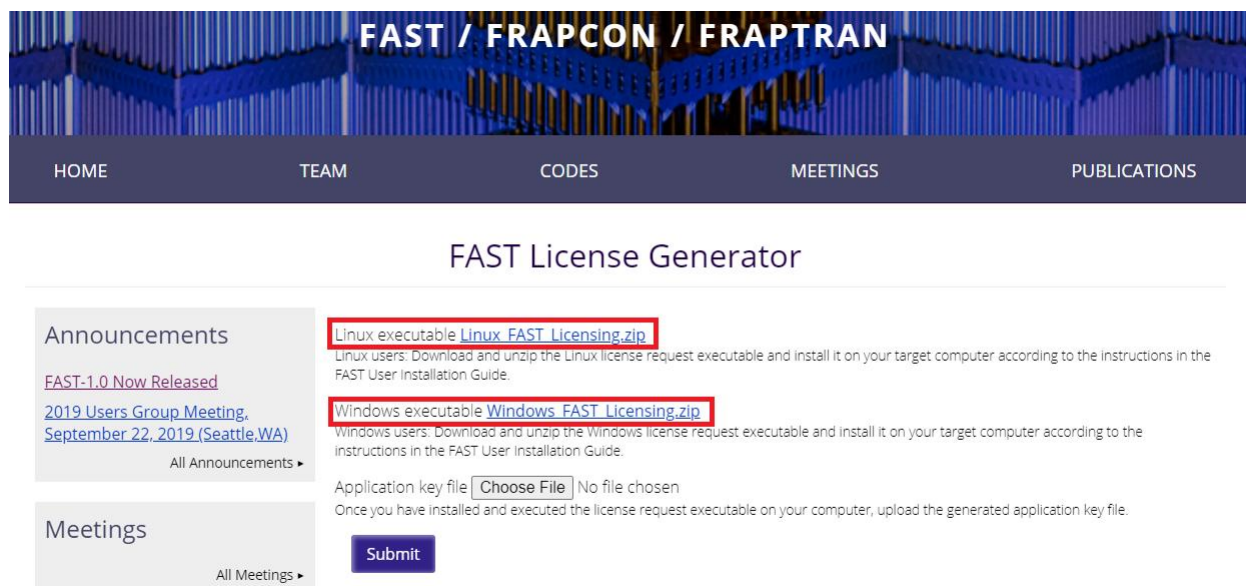


Figure 5: FAST Licensing Webpage

First select the appropriate licensing for the target machine's OS: Linux or Windows highlighted in red boxes in Figure 5. MacOS is currently not supported. There is a limit of 5 license files per website user. If you need more licenses, please contact PNNL through the website e-mail.

With the `CreateLicenseRequestFile(.exe)` on the target machine, execute the program as shown in Figures 6 and 7 depending upon your target machine's operating system.

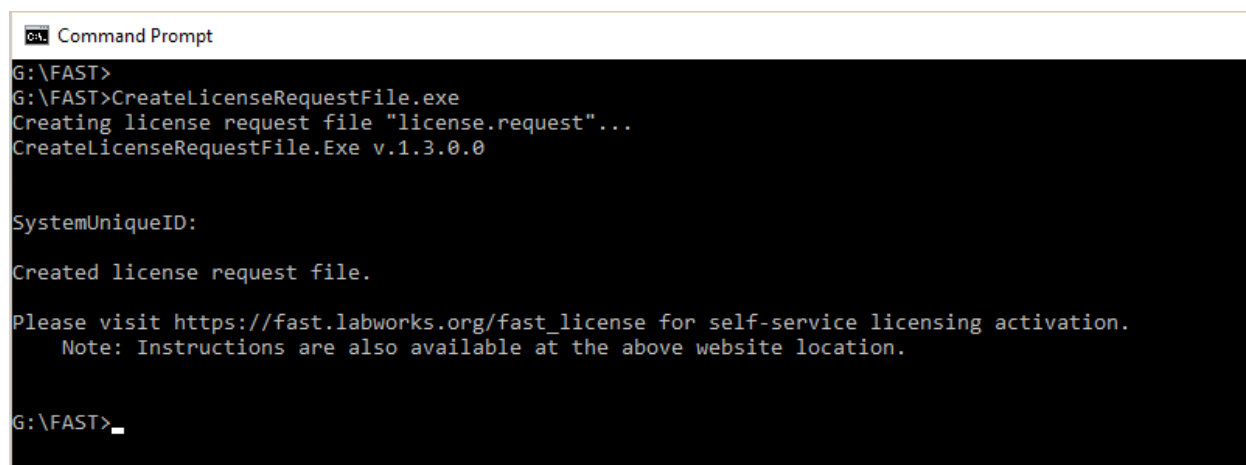


Figure 6: Windows License Request Generation

```

Test]$ ./CreateLicenseRequestFile
Creating license request file "license.request"...
CreateLicenseRequestFile.Exe v.1.3.0.0

SystemUniqueID:

Created license request file.

Please visit https://fast.labworks.org/fast_license for self-service licensing activation.
Note: Instructions are also available at the above website location.

[Test]$ █

```

Figure 7: Linux License Request Generation

A file named “license.request” is generated. Select “Choose File.”

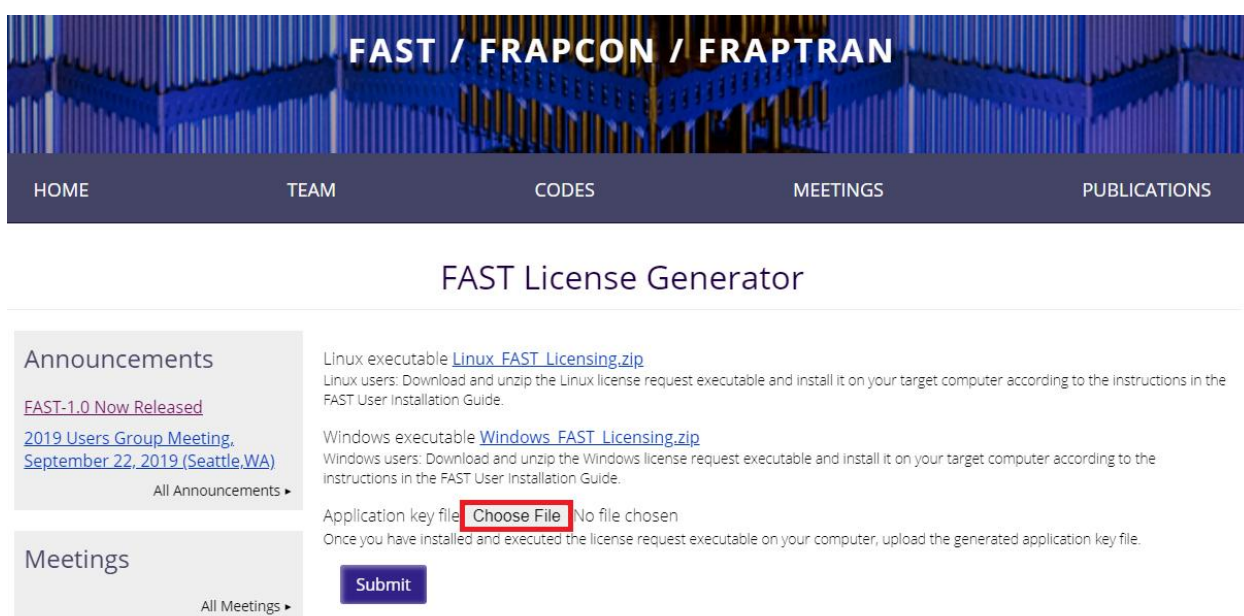
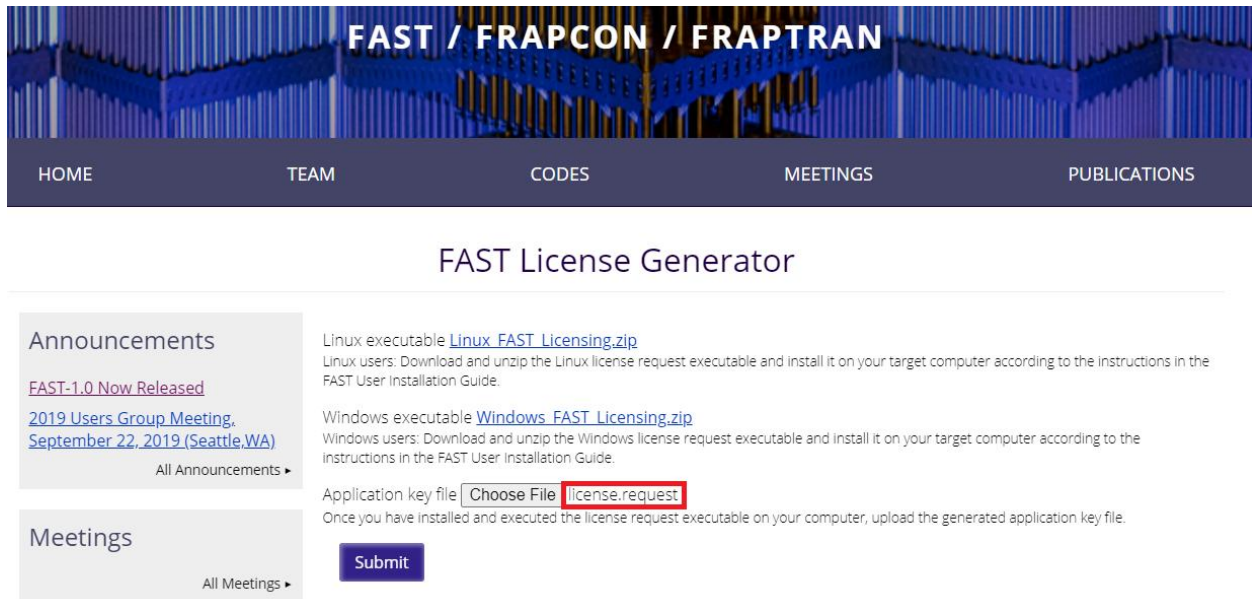


Figure 8: FAST License Request Website File Selection

Clicking “Choose File” highlighted in Figure 8 opens a File Explorer in Windows and a File Manager in Linux. Once a license.request file is selected, its name will appear to the right of the “Choose File” icon as seen in Figure 9 below. Do not change the name of the license.request file before uploading it. Click the “Submit” button which is also highlighted in red to create a FASTProduct.key.



FAST / FRAPCON / FRAPTRAN

HOME TEAM CODES MEETINGS PUBLICATIONS

FAST License Generator

Announcements

[FAST-1.0 Now Released](#)
[2019 Users Group Meeting, September 22, 2019 \(Seattle, WA\)](#)
All Announcements ▶

Meetings

All Meetings ▶

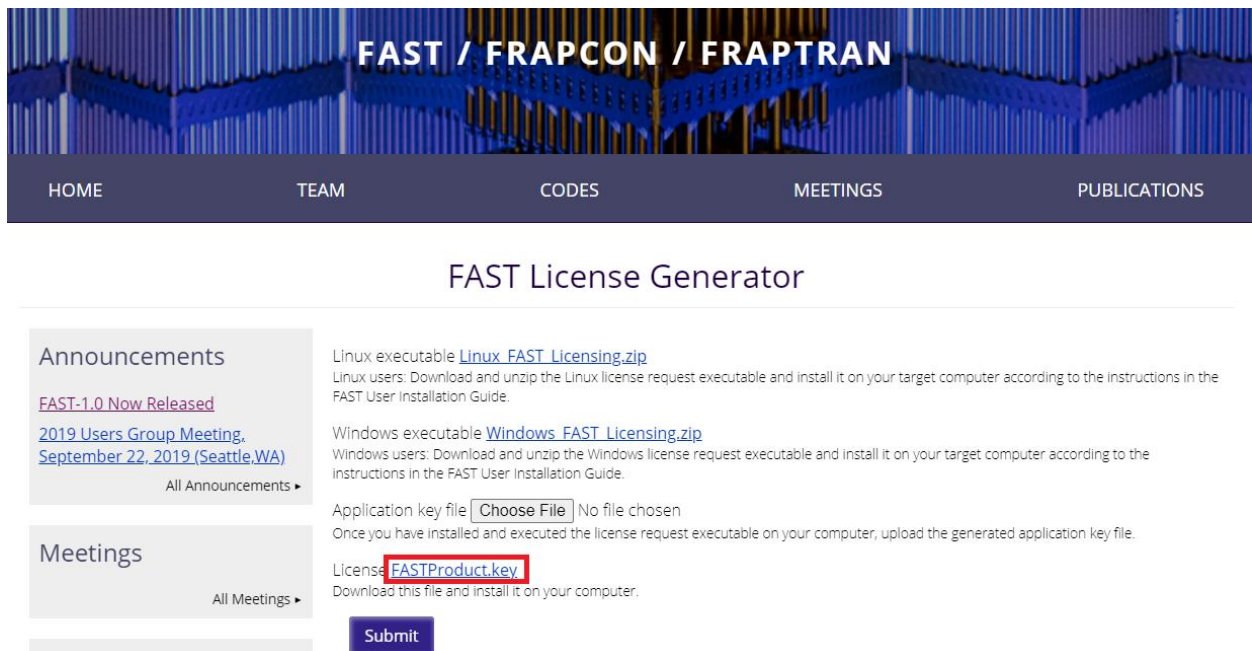
Linux executable [Linux FAST Licensing.zip](#)
Linux users: Download and unzip the Linux license request executable and install it on your target computer according to the instructions in the FAST User Installation Guide.

Windows executable [Windows FAST Licensing.zip](#)
Windows users: Download and unzip the Windows license request executable and install it on your target computer according to the instructions in the FAST User Installation Guide.

Application key file
Once you have installed and executed the license request executable on your computer, upload the generated application key file.

Figure 9: FAST License Request Website Submission

Clicking “Submit” generates the FASTProduct.key which shows up as a download link as highlighted in Figure 10 below. Download this file and place it in the same directory as the FAST execution on your target machine. Please do not change the name of this FASTProduct.key file. Your installation of FAST-1.2.2 is now complete and ready for verification testing in Section 3.0. It may be necessary to “right-click” the FASTProduct.key and choose “Save as”.



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[2019 Users Group Meeting, September 22, 2019 \(Seattle, WA\)](#)
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Linux executable [Linux FAST Licensing.zip](#)
Linux users: Download and unzip the Linux license request executable and install it on your target computer according to the instructions in the FAST User Installation Guide.

Windows executable [Windows FAST Licensing.zip](#)
Windows users: Download and unzip the Windows license request executable and install it on your target computer according to the instructions in the FAST User Installation Guide.

Application key file No file chosen
Once you have installed and executed the license request executable on your computer, upload the generated application key file.

License
Download this file and install it on your computer.

Figure 10: FAST License Request Completion

3.0 Installation Verification Suite

Now that your copy of FAST-1.2.2 has been downloaded and installed on the target machine in the target location (Section 1.0) and a FASTProduct.key (Section 2.0) has been obtained, the installation test suite can be executed. The FASTProduct.key must be in the location where you are running FAST-1.2.2 (where the outputs are generated). Typically, the user will run FAST-1.2.2 in a manner where the FAST-1.2.2 outputs are generated in the same location as the FAST-1.2.2 inputs by typing FAST-1.2.2 and the input file on the command line. The verification script keeps the inputs and outputs separate as a convenience to the user. The FASTProduct.key must be placed in the User_Verification_Outputs folder prior to executing the verification script.

If you run into errors when executing the verification script, please see Section 3.2 and the subsection that matches your OS. If your OS is a different version, the dependency instructions may still work, or they may need to be adjusted with the help of an internet search.

This section will describe the test suite and the steps to execute the testing automation script. The script verification_diff.py is written in Python 3 and used with Python 3.13 and 3.14 (as of January 2020 Python 2 was frozen and will no longer be developed). The script will execute the set of supplied FAST-1.2.2 inputs and provided files with the extension “.diff” that contain the differences between the FAST-1.2.2 output files generated on your machine and the output files generated by the FAST development team.

Use of a Python version other than 3.6 to 3.12 is possible; it is up to the person performing the testing to ensure that the diff files reflect the differences in output files. This can be done by spot checking a diff file and its associated files.

Tests included in the Verification Suite are listed in Table 5 below.

Table 5 – FAST-1.2.2 Verification Suite Tests

File Name	Test Name	Comments
FGR_BWstudR1.in	FGR_BWstudR1	B&W Studsvik Rod 1 for predicted fission gas release.
Oxide_N05.in	Oxide_N05	N05 Case for predicted oxide thickness.
Strain_GE7.in	Strain_GE7	GE7 Case for permanent hoop strain following a power ramp.
Temperature_681-3.in	Temperature_681-3	IFA-681 Rod 3 for predicted fuel centerline temperature.
Temperature_ifa_432r3.in	Temperature_ifa_432r3	IFA-432 Rod 3 for predicted fuel centerline temperature.
Void_24i6.in	Void_24i6	24i6 case for predicted end of life rod void volume.

To execute the Verification Suite first download and transfer the compressed file to the target machine. The `verification_diff.py` script must be updated if the FAST-1.2.2 executable is installed in a location other than that of the folder structure described in Table 4.

3.1 Expected Differences

The differences listed in this section were generated from machines which are less than 5 years old. Differences in architecture may result in round off error. The user is invited to use their professional judgement or contact PNNL via the website contact information for interpretation of larger than expected differences.

Sample difference files are included in the `Installation_Verification/Sample_Difference_Files/` folder. The testing conducted at PNNL using virtual machines and physical machines showed that the `verification_diff.py` script only shows file names and minor rounding. The script ignores expected differences in execution dates, usernames, and computer names. When Linux and Windows outputs are compared it was found that the peak axial node in a flat power profile changed but the fuel performance values remained the same.

Please see the `Sample_Difference_Files` folder for text files with differences. See Appendix A for a Windows difference file listing. The following is a listing of the Debian Trixie 13.5 differences, where some rounding occurs in the Temperature case, using Python 3:

```
*****
*****
|FGR_BWstudR1|

+++ /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/Verification_Cases/Outputs/FGR_BWstudR1
--- /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/User_Verification_Outputs/FGR_BWstudR1

#####
#####

*****
*****
|Oxide_N05|

+++ /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/Verification_Cases/Outputs/Oxide_N05
--- /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/User_Verification_Outputs/Oxide_N05

#####
#####

*****
*****
|Void_24i6|

+++ /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/Verification_Cases/Outputs/Void_24i6
--- /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/User_Verification_Outputs/Void_24i6

#####
#####
```

```

*****
*****
|Strain_GE7|

+++ /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/Verification_Cases/Outputs/Strain_GE7
--- /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/User_Verification_Outputs/Strain_GE7

#####
#####

*****
*****
|Temperature_681-3|

+++ /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/Verification_Cases/Outputs/Temperature_681-3
--- /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/User_Verification_Outputs/Temperature_681-3

+++ line:32633 5 74.0 3 1.02 2.79 464.1 474.9 485.6 2.27 639.6 774.9 868.9
0.0 -1614.3 -1017.9 0.1205 0.32499 717.1 340.2 0.0 0.01 11.8
--- line:32241 5 74.0 1 1.02 2.79 464.1 474.9 485.6 2.27 639.6 774.9 868.9
0.0 -1614.3 -1017.9 0.1205 0.32499 717.1 340.2 0.0 0.01 11.8
+++ line:32634 6 85.8 1 1.30 3.24 464.1 476.6 489.1 2.16 658.3 821.0 933.7
0.0 -1512.7 -970.4 0.1211 0.32521 758.5 354.0 0.0 0.01 11.9
--- line:32242 6 85.8 3 1.30 3.24 464.1 476.6 489.1 2.16 658.3 821.0 933.7
0.0 -1512.7 -970.4 0.1211 0.32521 758.5 354.0 0.0 0.01 11.9
+++ line:32639 11 136.2 3 2.66 4.32 464.2 480.8 497.5 1.84 687.0 932.7 1107.7
0.0 -1220.0 -833.4 0.1218 0.32586 902.7 393.9 0.0 0.01 12.3
--- line:32247 11 136.2 1 2.66 4.32 464.2 480.8 497.5 1.84 687.0 932.7 1107.7
0.0 -1220.0 -833.4 0.1218 0.32586 902.7 393.9 0.0 0.01 12.3
+++ line:32640 12 143.2 1 2.89 4.60 464.2 481.9 499.6 1.77 694.2 960.7 1153.4
0.0 -1148.1 -799.7 0.1256 0.32597 935.8 403.8 0.0 0.01 12.3
--- line:32248 12 143.2 6 2.89 4.60 464.2 481.9 499.6 1.77 694.2 960.7 1153.4
0.0 -1148.1 -799.7 0.1256 0.32597 935.8 403.8 0.0 0.01 12.3
+++ line:32642 14 157.2 1 3.36 5.47 464.2 485.3 506.3 1.64 718.1 1051.6 1298.5
0.0 -922.2 -694.0 0.1306 0.32627 1022.3 434.2 0.0 0.01 12.4
--- line:32250 14 157.2 6 3.36 5.47 464.2 485.3 506.3 1.64 718.1 1051.6 1298.5
0.0 -922.2 -694.0 0.1306 0.32627 1022.3 434.2 0.0 0.01 12.4
+++ line:32645 17 169.9 1 3.84 5.33 464.2 484.7 505.2 1.61 708.5 1039.6 1287.6
0.0 -933.7 -699.4 0.1315 0.32633 1037.8 433.0 0.0 0.02 12.4
--- line:32253 17 169.9 3 3.84 5.33 464.2 484.7 505.2 1.61 708.5 1039.6 1287.6
0.0 -933.7 -699.4 0.1315 0.32633 1037.8 433.0 0.0 0.02 12.4
+++ line:32646 18 176.9 9 4.12 5.57 464.2 485.7 507.1 1.56 712.7 1065.1 1332.6
0.0 -860.7 -665.2 0.1330 0.32644 1073.5 442.9 0.0 0.02 12.5
--- line:32254 18 176.9 6 4.12 5.57 464.2 485.7 507.1 1.56 712.7 1065.1 1332.6
0.0 -860.7 -665.2 0.1330 0.32644 1073.5 442.9 0.0 0.02 12.5
+++ line:32647 19 182.2 1 4.34 5.74 464.2 486.3 508.4 1.52 715.5 1084.5 1366.2
0.0 -807.4 -640.3 0.1341 0.32652 1098.8 450.4 0.0 0.02 12.5
--- line:32255 19 182.2 9 4.34 5.74 464.2 486.3 508.4 1.52 715.5 1084.5 1366.2
0.0 -807.4 -640.3 0.1341 0.32652 1098.8 450.4 0.0 0.02 12.5
+++ line:32648 20 188.8 1 4.64 6.27 464.2 488.3 512.4 1.43 724.1 1135.2 1455.5
0.0 -659.8 -571.2 0.1365 0.32670 1172.6 470.2 0.0 0.02 12.5
--- line:32256 20 188.8 9 4.64 6.27 464.2 488.3 512.4 1.43 724.1 1135.2 1455.5
0.0 -659.8 -571.2 0.1365 0.32670 1172.6 470.2 0.0 0.02 12.5
+++ line:32651 23 207.1 1 5.48 6.65 464.3 489.8 515.4 1.31 721.4 1175.6 1538.5
0.0 -510.0 -501.0 0.1393 0.32696 1278.7 490.8 0.0 0.02 12.6
--- line:32259 23 207.1 9 5.48 6.65 464.3 489.8 515.4 1.31 721.4 1175.6 1538.5
0.0 -510.0 -501.0 0.1393 0.32696 1278.7 490.8 0.0 0.02 12.6
+++ line:32653 25 232.5 3 6.71 6.68 464.3 490.0 515.7 1.26 714.6 1191.0 1585.2
0.0 -424.9 -461.2 0.1410 0.32707 1331.0 502.3 0.1 0.02 12.7
--- line:32261 25 232.5 6 6.71 6.68 464.3 490.0 515.7 1.26 714.6 1191.0 1585.2
0.0 -424.9 -461.2 0.1410 0.32707 1331.0 502.3 0.1 0.02 12.7
+++ line:32654 26 235.6 9 6.87 7.07 464.3 491.4 518.6 1.19 718.1 1229.2 1654.5
0.0 -304.4 -404.8 0.1426 0.32720 1402.8 518.6 0.1 0.02 12.7

```

```

--- line:32262 26 235.6 1 6.87 7.07 464.3 491.4 518.6 1.19 718.1 1229.2 1654.5
0.0 -304.4 -404.8 0.1426 0.32720 1402.8 518.6 0.1 0.02 12.7
+++ line:32655 27 243.5 1 7.27 6.96 464.3 491.0 517.8 1.12 702.6 1269.3 1796.2
0.0 -122.4 -319.6 0.1439 0.32736 1492.7 543.3 0.1 0.02 12.7
--- line:32263 27 243.5 6 7.27 6.96 464.3 491.0 517.8 1.12 702.6 1269.3 1796.2
0.0 -122.4 -319.6 0.1439 0.32736 1492.7 543.3 0.1 0.02 12.7
+++ line:32660 32 281.6 1 9.23 7.52 464.3 493.2 522.1 0.98 698.0 1327.3 1914.4
0.0 136.1 -198.6 0.1551 0.32764 1692.6 578.4 0.1 0.02 12.9
--- line:32268 32 281.6 6 9.23 7.52 464.3 493.2 522.1 0.98 698.0 1327.3 1914.4
0.0 136.1 -198.6 0.1551 0.32764 1692.6 578.4 0.1 0.02 12.9
+++ line:32664 36 321.9 3 11.41 7.52 464.4 493.2 522.1 0.95 693.8 1333.7 1928.5
0.0 210.4 -163.8 0.1624 0.32775 1734.1 589.0 0.1 0.02 13.0
--- line:32272 36 321.9 1 11.41 7.52 464.4 493.2 522.1 0.95 693.8 1333.7 1928.5
0.0 210.4 -163.8 0.1624 0.32775 1734.1 589.0 0.1 0.02 13.0
+++ line:32694 x Axial node = 3 x
--- line:32302 x Axial node = 6 x
+++ line:32707 x Axial node = 1 x
--- line:32315 x Axial node = 4 x
#####
#####

*****
*****
|Temperature_ifa-432r3|

+++ /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/Verification_Cases/Outputs/Temperature_ifa-432r3
--- /home/cola105/FAST-1.2.2_Debian-
13.5.0/Installation_Verification/User_Verification_Outputs/Temperature_ifa-432r3

#####
#####

```

3.2 Installing FAST-1.2.2 Dependencies

FAST-1.2.2 was compiled using Intel OneAPI. Prior compilations for Linux were completed using gcc, where most Linux OS installations have gcc libraries installed. The following steps were taken for the following OS installations to successfully run FAST-1.2.2 with the installation test suite.

Note that you may need someone with admin privileges to properly install these libraries properly for single and multiple user machines.

3.2.1 OpenSUSE 16 Leap

To install Intel oneAPI libraries, the following commands were executed to add the repository and install the libraries:

```

sudo zypper addrepo https://yum.repos.intel.com/oneapi oneAPI

sudo rpm --import https://yum.repos.intel.com/intel-gpg-keys/GPG-PUB-KEY-
INTEL-SW-PRODUCTS.PUB

sudo zypper refresh

sudo zypper install intel-oneapi-compiler-dpcpp-cpp-runtime

source /opt/intel/oneapi/setvars.sh

```

The commands above must be run prior to execution of the verification_diff.py script.

3.2.2 Ubuntu 26.04 LTS, Linux Mint 22.3, Debian 13.5.0

To install the Intel oneAPI libraries, the following commands were executed to add the repository and install the libraries:

```
wget -O- https://apt.repos.intel.com/intel-gpg-keys/GPG-PUB-KEY-INTEL-SW-PRODUCTS.PUB \
| gpg --dearmor | sudo tee /usr/share/keyrings/oneapi-archive-keyring.gpg > /dev/null

echo "deb [signed-by=/usr/share/keyrings/oneapi-archive-keyring.gpg]
https://apt.repos.intel.com/oneapi all main" \
| sudo tee /etc/apt/sources.list.d/oneAPI.list

sudo apt update

sudo apt install intel-oneapi-compiler-dpcpp-cpp-runtime

source /opt/intel/oneapi/setvars.sh
```

The commands above must be run prior to execution of the `verification_diff.py` script.

3.3 FAST-1.2.2 Code Change Requests

NQA-1-2017 is a more rigorous quality assurance program, however issues with code may arise. Please use the form in Appendix B to request changes and e-mail it to PNNL via the contact information on the FAST website.

4.0 Convenience Scripts

A convenience script that converts FRAPCON input to FAST input is included. FAST-1.2.2 performs calculations for normal operations and AOOs. FRAPTRAN initialized with FRAPCON will be used for design basis accidents such as RIAs and LOCAs. The convenience script contains preliminary conversions for standalone FRAPTRAN inputs however the FAST-1.2.2 code is only for normal operations and AOOs.

4.1 Execution of FRAPCON_to_FAST.py

The Python3 script `FRAPCON_to_FAST_Inputs.py` will convert FRAPCON inputs to FAST inputs. The script retains the order of the variables from the FRAPCON input in the FAST input for easier comparisons. Changes to Fortran NAMELIST block beginnings and endings are included for compliance with the latest Fortran standards. The previous files used Intel formatting which can be slightly different from the general Fortran standard. The user of the script will find indices added to arrays and comments added for each variable. Please note that the FRAPCON input file can only have one instance of each NAMELIST block to properly work.

Execution of the script is best performed in a new directory with input files containing the ending with “.in”. The script will convert FRAPCON files by writing a new file with the ending `_FAST.in`. Executing the command `python3 FRAPCON_to_FAST_Inputs.py all` will convert all files in the working directory. Executing the command `python3 FRAPCON_to_FAST_Inputs.py 24i6.in` will only convert the file name given to `24i6_FAST.in`.

4.2 FAST-1.2.2 AIG

The Microsoft Excel-based tool for generating input, developed for use with the FAST codes is FAST-1.2.2 AIG. This auto input-generator is similar to the AIG for FRAPCON and FRAPTRAN but with differences for FAST.

It is highly recommended that this Auto Input Generator be used to build FAST inputs to avoid errors in the input file. Even if users are going to modify the input, it is recommended that users first start with the AIG input, run the input to see that it works and then make modifications from there.

Updates to the FAST-1.2.2 AIG from the FAST-1.2.1 AIG:

- Added a clear option for the auto input.
- Removed the `psia` column from the power history tab when it's determined not to be needed or used in the AIG.
- Added the ability to create a radial power profile
- Added the processing for the `nthermex` variable
- Added a write/create file button
- Fixed the spent fuel Generate Boundary Conditions button. Previously, it was required to click this button two times to correctly update these conditions.
- Extended the Power History from 1000 to 9999.

4.3 FRAPlot

The Microsoft Excel-based tool for plotting developed for use with the FAST codes is FRAPlot. Instructions for its use are located in Appendix C, Section C.3, in FAST-1.2.2: A Computer Code for Thermal-Mechanical Nuclear Fuel Analysis under Steady-state and Transients, PNNL-39254.

No changes were made to FRAPlot since the release of FAST-1.2.1.

5.0 References

The following documents were utilized to develop and/or are referenced in this document:

- 10 CFR, Title 10 Code of Federal Regulations, United State Government, 2018.
- ASME NQA-1-2017, Quality Assurance Requirements for Nuclear Facility Applications, January 18, 2018.
- DOE G 414.1-4, Safety Software Guide for use with 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance, November 2010.
- NRC NUREG/BR-0167 Software Quality Assurance Program and Guidelines, February 1993.
- PNNL-39254, FAST-1.2.2: A Computer Code for Thermal-Mechanical Nuclear Fuel Analysis under Steady State and Transients, Revision 0, May 2026.

Appendix A – Windows Server 2025 Standard Differences

The following difference is a comparison of Windows Server 2025 Standard with files run on Windows 11. Only the file names are written to the .txt file. Rounding may occur with your setup depending upon hardware architecture.

```
*****
*****
|FGR_BWstudR1|

+++ C:\Users\Administrator\Documents\FAST-
1.2.2\Installation_Verification\Verification_Cases\Outputs\FGR_BWstudR1
--- C:\Users\Administrator\Documents\FAST-
1.2.2\Installation_Verification\User_Verification_Outputs\FGR_BWstudR1

#####
#####

*****
*****
|Oxide_N05|

+++ C:\Users\Administrator\Documents\FAST-1.2.2\Installation_Verification\Verification_Cases\Outputs\Oxide_N05
--- C:\Users\Administrator\Documents\FAST-1.2.2\Installation_Verification\User_Verification_Outputs\Oxide_N05

#####
#####

*****
*****
|Strain_GE7|

+++ C:\Users\Administrator\Documents\FAST-1.2.2\Installation_Verification\Verification_Cases\Outputs\Strain_GE7
--- C:\Users\Administrator\Documents\FAST-1.2.2\Installation_Verification\User_Verification_Outputs\Strain_GE7

#####
#####

*****
*****
|Temperature_681-3|

+++ C:\Users\Administrator\Documents\FAST-
1.2.2\Installation_Verification\Verification_Cases\Outputs\Temperature_681-3
--- C:\Users\Administrator\Documents\FAST-
1.2.2\Installation_Verification\User_Verification_Outputs\Temperature_681-3

+++ line:32639 11 136.2 3 2.66 4.32 464.2 480.8 497.5 1.84 687.0 932.7 1107.7 0.0 -1220.0
-833.4 0.1218 0.32586 902.7 393.9 0.0 0.01 12.3
--- line:32639 11 136.2 6 2.66 4.32 464.2 480.8 497.5 1.84 687.0 932.7 1107.7 0.0 -1220.0
-833.4 0.1218 0.32586 902.7 393.9 0.0 0.01 12.3
+++ line:32640 12 143.2 1 2.89 4.60 464.2 481.9 499.6 1.77 694.2 960.7 1153.4 0.0 -1148.1
-799.7 0.1256 0.32597 935.8 403.8 0.0 0.01 12.3
--- line:32640 12 143.2 6 2.89 4.60 464.2 481.9 499.6 1.77 694.2 960.7 1153.4 0.0 -1148.1
-799.7 0.1256 0.32597 935.8 403.8 0.0 0.01 12.3
+++ line:32647 19 182.2 1 4.34 5.74 464.2 486.3 508.4 1.52 715.5 1084.5 1366.2 0.0 -807.4
-640.3 0.1341 0.32652 1098.8 450.4 0.0 0.02 12.5
--- line:32647 19 182.2 9 4.34 5.74 464.2 486.3 508.4 1.52 715.5 1084.5 1366.2 0.0 -807.4
-640.3 0.1341 0.32652 1098.8 450.4 0.0 0.02 12.5
+++ line:32653 25 232.5 3 6.71 6.68 464.3 490.0 515.7 1.26 714.6 1191.0 1585.2 0.0 -424.9
-461.2 0.1410 0.32707 1331.0 502.3 0.1 0.02 12.7
--- line:32653 25 232.5 9 6.71 6.68 464.3 490.0 515.7 1.26 714.6 1191.0 1585.2 0.0 -424.9
-461.2 0.1410 0.32707 1331.0 502.3 0.1 0.02 12.7
+++ line:32661 33 295.6 1 10.00 7.59 464.4 493.5 522.6 0.97 697.9 1338.2 1935.0 0.0 185.4
-175.5 0.1587 0.32770 1714.5 585.5 0.1 0.02 12.9
--- line:32661 33 295.6 9 10.00 7.59 464.4 493.5 522.6 0.97 697.9 1338.2 1935.0 0.0 185.4
-175.5 0.1587 0.32770 1714.5 585.5 0.1 0.02 12.9
+++ line:32663 35 314.4 1 11.00 7.52 464.4 493.2 522.1 0.96 694.7 1332.5 1926.1 0.0 199.0
-169.2 0.1612 0.32773 1725.6 587.2 0.1 0.02 13.0
--- line:32663 35 314.4 9 11.00 7.52 464.4 493.2 522.1 0.96 694.7 1332.5 1926.1 0.0 199.0
-169.2 0.1612 0.32773 1725.6 587.2 0.1 0.02 13.0
+++ line:32664 36 321.9 3 11.41 7.52 464.4 493.2 522.1 0.95 693.8 1333.7 1928.5 0.0 210.4
-163.8 0.1624 0.32775 1734.1 589.0 0.1 0.02 13.0
```

```

-- line:32664 36 321.9 6 11.41 7.52 464.4 493.2 522.1 0.95 693.8 1333.7 1928.5 0.0 210.4
-163.8 0.1624 0.32775 1734.1 589.0 0.1 0.02 13.0
+++ line:32707 x Axial node = 1 x
--- line:32707 x Axial node = 4 x
#####
#####

*****
*****
|Temperature_ifa-432r3|

+++ C:\Users\Administrator\Documents\FAST-
1.2.2\Installation_Verification\Verification_Cases\Outputs\Temperature_ifa-432r3
--- C:\Users\Administrator\Documents\FAST-
1.2.2\Installation_Verification\User_Verification_Outputs\Temperature_ifa-432r3

#####
#####

*****
*****
|Void_24i6|

+++ C:\Users\Administrator\Documents\FAST-1.2.2\Installation_Verification\Verification_Cases\Outputs\Void_24i6
--- C:\Users\Administrator\Documents\FAST-1.2.2\Installation_Verification\User_Verification_Outputs\Void_24i6

#####
#####

```

Appendix B – FAST Change Request Form

The following form can e-mailed to PNNL via the FAST website contact information to request a change or report a software deficiency.

(select one)

No. _____

(Assigned by PM)

1. RELEASED VERSION ID. _____
2. REQUESTOR _____ PHONE ____/____
3. ERROR REPORTED: ☐ YES ☐ NO E-MAIL _____
4. PROJECTED START DATE: _____
5. ESTIMATED TIME FOR COMPLETION: _____
6. DESCRIPTION (attach continuation sheets if necessary)

7. REASON FOR MODIFICATION (attach continuation sheets if necessary)

8. CODE PERFORMANCE IMPACTS (If applicable)

To be completed by PM

ACTION: APPROVED DENIED

DATE RECEIVED _____

ASSIGNED TO _____

Approval for new modification _____ Date _____

Pacific Northwest National Laboratory

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99354
1-888-375-PNNL (7665)

www.pnnl.gov | www.nrc.gov