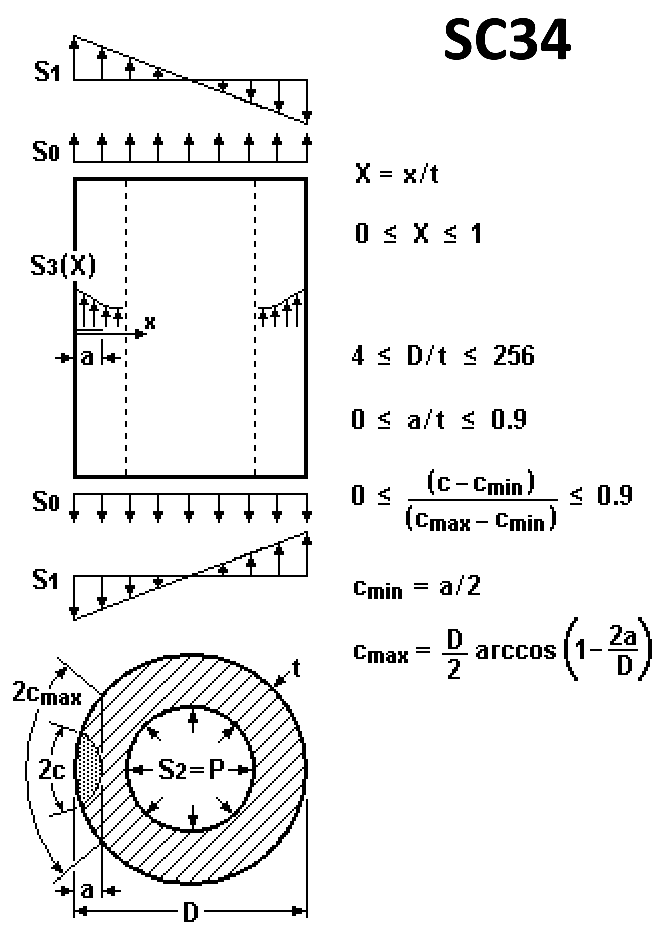
July 1, 2020

NASGRO v9.2 Release Notes

New and Improved Stress Intensity Factor (SIF) Models:

- **New WF Model for External Surface Crack in Hollow Cylinder (SC34):**

Crack case SC34 is a new weight function (WF) solution for an external circumferential surface crack in a hollow cylinder. SC34 employs a new geometric parameterization for the crack front that maintains a semi-elliptical crack front for all allowable crack configurations. It positions the crack to intersect the free surface at a normal angle and supports two degrees of freedom for the crack front. SC34 employs a new set of reference solutions with much higher fidelity than earlier analyses. SC34 enables nonlinear stresses applied across the thickness as either a user-defined service stress or as a residual stress. As a result, SC34 provides a wider range of options than SC05 even though they share the same nominal description. SC34 is limited to cracks on the exterior of the cylinder. SC34 does not transition to any other crack cases.



Notes: Internal pressure (S2) implies that the cylinder is capped and generates an additional axial stress.

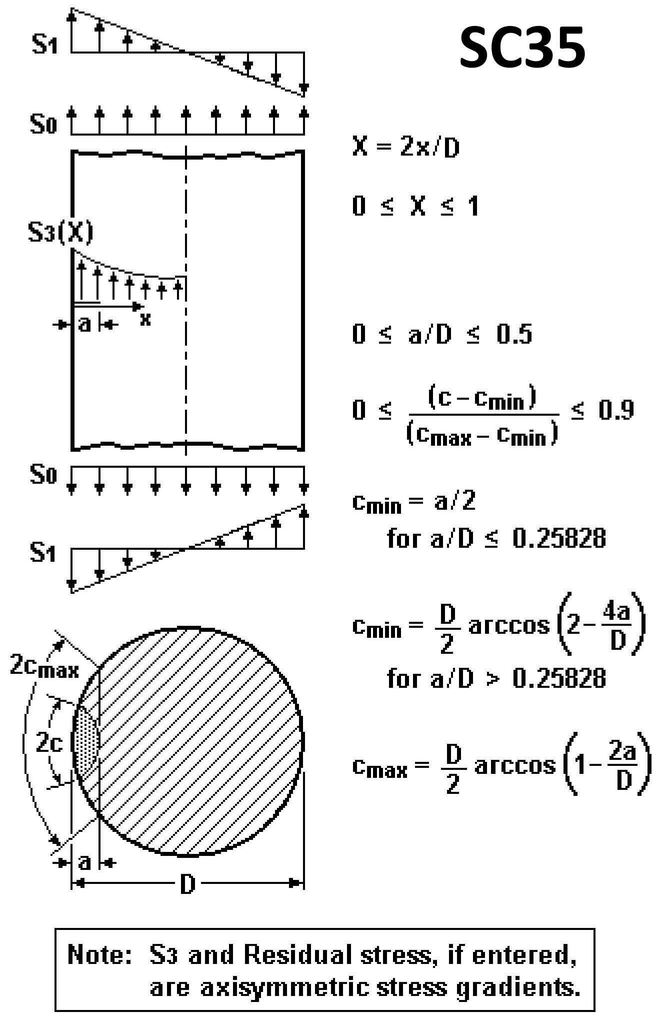
S3 and Residual stress, if entered, are axisymmetric stress gradients.

SC34 supports remote tension and bending stresses (S0 and S1) and an internal pressure (S2) that creates an additional axial stress. It is also possible to enter an axisymmetric through-thickness univariant stress gradient normal to the crack plane in tabular form (S3) as well as an axisymmetric residual stress distribution. SC34 supports the FAD failure criterion in NASFLA.

Additional detail on the development and verification of this new model is contained in Appendix C of the Reference Manual.

- **New WF Model for External Surface Crack in Solid Cylinder (SC35):**

Crack case SC35 is a new weight function (WF) solution for an external circumferential surface crack in a solid cylinder. SC35 employs a new geometric parameterization for the crack front that maintains a semi-elliptical crack front for all allowable crack configurations. It positions the crack to intersect the free surface at a normal angle and supports two degrees of freedom for the crack front. SC35 employs a new set of reference solutions with much higher fidelity than earlier analyses. SC35 enables nonlinear stresses applied as either a user-defined service stress or as a residual stress. As a result, SC35 provides a wider range of options than SC07 even though they share the same nominal description. SC35 is a complete solution that does not transition to any other crack cases.

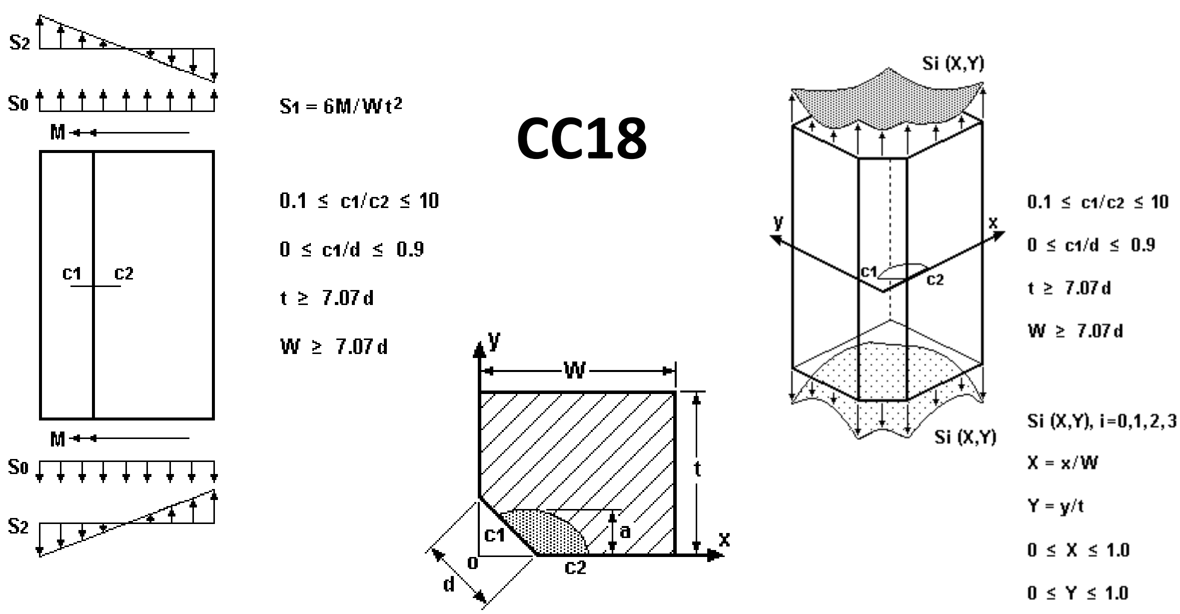


SC35 supports remote tension and bending stresses (S0 and S1). It is also possible to enter an axisymmetric through-thickness univariant stress gradient normal to the crack plane in tabular form (S3) as well as an axisymmetric residual stress distribution. SC35 is not yet enabled to use the FAD failure criterion in NASFLA.

Additional detail on the development and verification of this new model is contained in Appendix C of the Reference Manual.

- **New Bivariant WF Model for Part-elliptical Corner Crack at Angled Corner (135^o) (CC18):**

  This new bivariant weight function model represents a part-elliptical corner crack at a 135^o angled corner. The angled corner may be a result from 45^o chamfering at a 90^o corner. In contrast to the CC12 crack case, the CC18 corner crack does not enclose the whole chamfer. By definition, its requirement assumes the surface crack length along the chamfer direction is less than any chamfer width. In addition, two dissimilarities should be singled out for clarification. First, different length parameters relating to chamfer are designated. The chamfer length parameter with CC12 is the chamfer depth measured from the imaginary 90^o corner of the rectangular cross section to the chamfer corner. For comparison, the parameter with CC18 is the chamfer width measured between the two angled corners. Second, the centers of the corner crack are also designated differently. The crack center of CC12 crack model is at the imaginary 90^o corner, while the center of CC18 crack model is always at the lower angled corner of the chamfer. Such minute differences lead to different definitions of surface crack lengths in both models. The crack growth algorithm assumes the growth at the *c*1-tip, or the surface crack tip along the chamfer direction may eventually pass beyond the solution limit and this part-elliptical corner crack would transition into a CC12 corner crack.



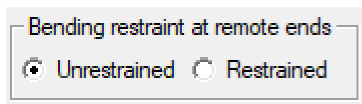
Remote Tension & Bending **2D Tabular Stress Gradient**

SC18 is not enabled to use the FAD failure criterion in NASFLA. Additional detail on the development and verification of this new model is contained in Appendix C of the Reference Manual.

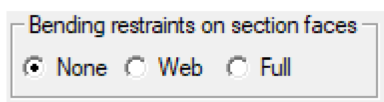
- **Addition of Restraint Options for Multiple Stress Intensity Factor Models**

For NASGRO v9.2, a number of SIF models were enhanced to provide options for modifying the restraints (boundary conditions) on the geometry. These new capabilities are summarized below. For all of these cases, the pictorial view of the model shown in the GUI automatically adjusts to illustrate the restraint conditions selected.

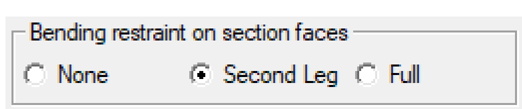
Addition of end restraints for TC12, TC15, TC17, TC19, TC25. For these five crack cases, v9.2 now enables users to select a restrained geometric solution in addition to the (default) unrestrained solution. The restrained solutions prohibit in-plane rotation at the far-end of the plate. The restrained solutions lead to less conservative stress intensity factor values than the (default) unrestrained solution for long cracks. To specify the bending restraint boundary conditions for these models, the "restrained" radio button on the geometry page should be checked:



Addition of partial bending restraints on section faces for TC37. For this crack case, a through crack in a channel section under remote loading, v9.2 now enables users to select between two restrained geometric solutions in addition to the (default) unrestrained solution. Restrained geometric solution options are provided for bending restraint of the web (only) or for full bending restraint (of the web and flanges). The restrained solutions lead to less conservative stress-intensity factor values than the (default) unrestrained solution for long cracks. To specify the bending restraint boundary conditions for this model, the "Web" or "Full" radio button on the geometry page should be checked:

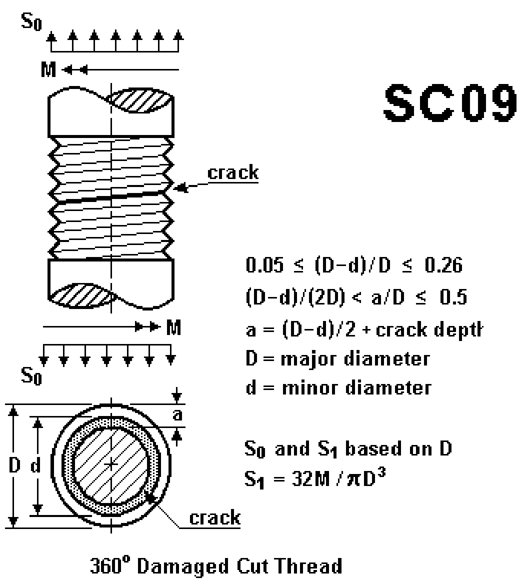


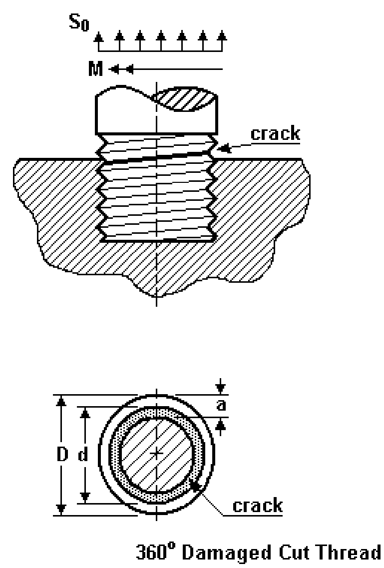
Addition of partial bending restraints on section faces for TC31 and TC32. For these two crack cases, through cracks in an angle section under remote loading, v9.2 now enables users to select between two restrained geometric solutions in addition to the (default) unrestrained solution. Restrained geometric solution options are provided for bending restraint of the second (vertical) leg (only) or for full bending restraint (of both legs of the angle). The restrained solutions lead to less conservative stress-intensity factor values than the (default) unrestrained solution for long cracks. To specify the bending restraint boundary conditions for these models, the "Second Leg" or "Full" radio button on the geometry page should be checked:



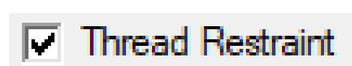
- **New Thread Restraint Option for Circumferential Surface Crack in Threaded Solid Cylinder (SC09)**

  The original (legacy) SC09 solution actually represented remote loadings at both ends of a threaded cylinder with a circumferential surface crack. The diagram in the SC09 GUI has been revised to reflect this geometry and is shown on the left below. This is the default boundary condition for SC09. For v9.2, a new SIF solution for the thread restraint (nut-loaded) boundary condition was introduced as an option to the existing crack case for SC09. A "Thread Restraint" check box in the SC09 GUI activates this new option (see below right). The new SIF solution option accounts for a more critical scenario when the cracked thread is constrained by the nut or base on one side and the cylinder (or bolt) is loaded in tension and bending at the opposite remote end. This boundary condition results in higher SIF levels relative to the default remote loading condition at both ends because of the higher stress concentration factor induced at the thread root. Details of the new SIF solutions implemented as well as the results from the SIF verification study for both boundary conditions are provided under SC09 section in the Appendix C of the NASGRO Reference Manual.





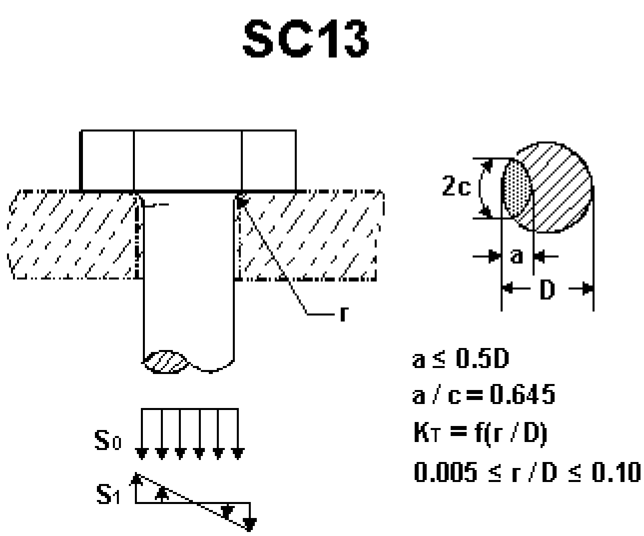
Original (Legacy) SC09 Solution **New Thread Restraint SC09 Solution**



- **Improved Bending (F1) Solution for Surface Crack in Bolt Head Fillet (SC13)**

  The stress intensity factor solution for a semi-elliptical surface crack at a bolt head fillet under bending (F1) was refined in v9.2. The F1 geometry factor values due to bending were revised to better match new FEA results obtained with StressCheck. There was no change to the tension, F0, solution.

  A new stress concentration Kt table specific to bending loading was added to the solution, which is used to estimate the limiting geometry factor value at zero crack size. Previously, the stress concentration solution for tension was being used to estimate F1 for bending. Because the Kt values for bending are relatively lower than Kt for tension, the updated F1 values are also lower for small crack sizes; therefore, the new and more accurate SIF solution for bending is expected to result in a longer crack propagation lives in NASFLA. Tables of the revised Kt values for bending are provided in the SC13 section of Appendix C of the NASGRO manual. Results of the verification study for bending loading before and after the refinement are also provided in Appendix C of the NASGRO Reference Manual.



Shear or Machine Bolt - Machined Fillet

- **Expanded Solution Limits and Other SIF Model Improvements:**

  - ***Univariant WF solution for curved crack in plate (TC28)***

    The maximum allowable W/t ratio for TC28 was expanded from 20 to 100 to account for thin plate configurations. This extension only applies to the "unrestrained" bending condition. For the "restrained" boundary condition, the solution limits remain the same; *i.e.*, the upper limit of *W/t* ratio is 20.

  - ***Univariant WF solution for corner crack at offset hole in plate (CC08)***

    The hole offset limits for cracks on the short ligament side of the hole were expanded from $0.2 \leq 2B/W \leq 1.0$ to $\mathbf{0.1} \leq 2B/W \leq 1.0$.

  - ***Two unequal through cracks at offset hole in plate (TC23)***

    The TC23 SIF solution was improved by modifying the compounding procedure for bending and by developing additional geometry factors for tension, bending, and pin load. The improved TC23 solutions work reasonably well for all three load types (tension, bending and pin load) within the following geometry and crack size limits:

    $$\min(B;W - B)/R \geq 1.25; \quad c/(B - R) \leq 0.9; \quad c1/(W - B - R) \leq 0.9$$

    The crack size limit for both c and c1 (0.9) was further increased to 0.95 since the one-crack solutions have been verified working well up to 0.95. Appendix C compares the previous and improved TC23 solutions for all three load cases with FEA results verifying the improved solutions.

  - ***Improved reference solutions for TC17 and TC19***

    Beginning with v9.2a, the weight function formulation deployed in these two crack cases (TC17 and TC19) has been revised to resolve the inconsistencies identified in prior versions for very small cracks. These revisions will result in longer lifetimes when compared to the previous formulation. It should be noted that not all SIF solutions in this crack case are derived from the weight function method. The exceptions are applied to those specific scenarios where the plate is subjected to uniform tension at the remote ends that are restrained from bending, where interpolated results from the reference solutions are used directly.

  - ***Transition from CC16 to TC23 for long ligament crack***

    The Fawaz-Anderson corner crack model (CC16) was enhanced to automatically transition to TC23 for cracks originating in the long ligament side (B > W/2).

- ***Univariant WF solution for constant-depth circumferential surface crack in hollow cylinder (SC06)***

  The upper limit of the SC06 crack size was increased from $a/t = 0.85$ to $a/t = 0.95$. The underlying SIF model was not changed, so the model behaves the same way within the previously defined crack size region (i.e. $a/t \leq 0.85$). Verification studies were carried out for both internal and external cracks to show the validity of the existing weight-function methodology for the crack sizes up to $a/t = 0.95$. The results of the verification studies are provided in Appendix C of the Reference Manual.

- ***Constant depth circumferential surface crack in threaded hollow cylinder (SC10)***

  A verification study was performed on the SIF solutions for crack case SC10. Revised model validity regions were imposed in the NASFLA and NASSIF GUIs based on the outcome. Beginning with v9.2b, the new limits imposed for SC10 are as follows (previously, this crack case did not have any specified geometry limits):

$$0 \leq \frac{D-d}{D_o - D_i} \leq 0.5$$

$$0.1 \leq D_i/D_o \leq 0.9$$

$$\frac{D-d}{2t} < a/t \leq 0.95$$

  In the above, D_i and D_o are the inside and outside diameters. D and d are the thread major and minor diameters. These new limits and the verification results are provided in Appendix C of the Reference Manual.

- ***Compounding Capabilities for Models TC31, TC32, and TC37***

  Compounding capabilities have been implemented for the L-section (TC31 and TC32) and C-section (TC37) structural section models.

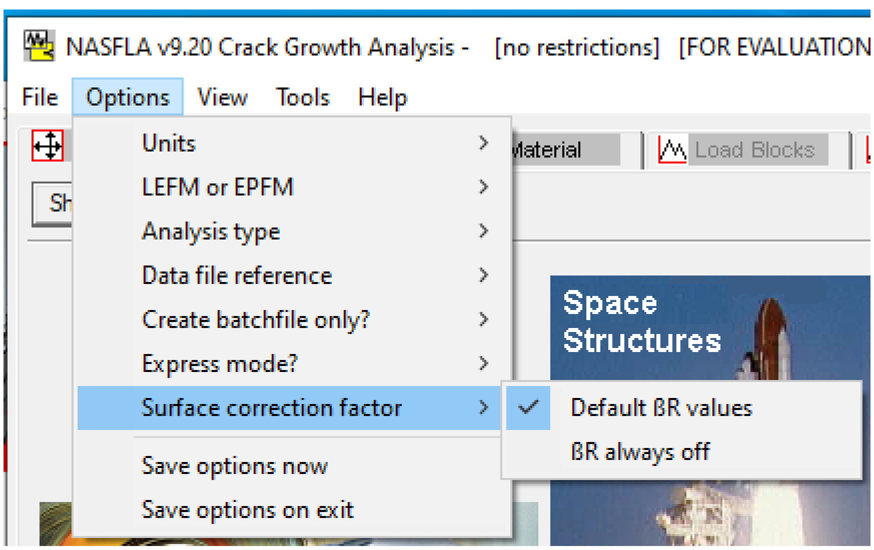
Documentation of Selected SIF Verification Studies:

Appendix C of the Reference Manual (Stress Intensity Factor Formulations) has been revised to include documentation of recent verification studies for six weight function crack cases (CC09, CC11, EC04, EC05, SC30, SC31). NASGRO SIF calculations were compared with thousands of independent high quality three-dimensional finite element SIF calculations covering a wide range of crack sizes, crack shapes, and applied stress gradients. Over 90% of the NASGRO solutions were found to be within 5% of the benchmark FE solutions (most were within 3%). Larger errors were generally associated with configurations of little or no practical significance.

New Surface Crack Closure Correction Factor Option:

The surface crack closure factor, β_R, has been used in NASGRO (NASFLA) as a multiplier on ΔK Using this factor has been shown to produce more accurate crack growth predictions for semi-elliptical surface cracks and quarter-elliptical corner cracks. This β_R factor is only applied at points where the part-through crack front intersects a free surface, and it is a function of the stress ratio. Details of this surface crack closure factor are described in Section 2.1.2 of the main NASGRO manual and in Section 15 of Appendix C. Table 15.0.1 of Appendix C lists the crack cases that utilize the surface crack closure correction factor.

In previous versions of NASGRO, the surface crack closure correction factor was applied automatically (by default) in NASFLA and it was not possible for the user to deactivate its use. Now, in NASGRO v9.2, an option has been added to the Options menu to allow the user to turn off the β_R factor for all crack cases:



The default is to have the use of the β_R factor <u>active</u> for the applicable crack cases, as listed in Table 15.0.1 of Appendix C. Therefore, keeping the β_R factor active is recommended.

Implementation of the Surface Crack Closure Correction Factor for CC09, CC11, & CC12

The surface crack closure factor, β_R, has been implemented for the bivariant weight function corner crack models CC09, CC11 and CC12. This change makes these models consistent with the application of the β_R factor on other corner crack models. The inclusion of the β_R factor on these corner crack models will result in a significant increase in life, on the order of as much as 40 percent.

Limits on Threshold Fanning Paramters (Cth and Fth) in NASFLA and NASMAT

The threshold fanning parameters Cth+ and Fth+ define the slope of the threshold value (ΔKth) against R in the NASGRO equation for positive stress ratios. Within both NASMAT and NASFLA, the upper and lower limits are 10 and -0.5 for Cth+ and 8 and 0 for Fth+. NASMAT will not fit values outside these bounds or save a fit in which the user has manually entered values outside these bounds. NASFLA will not run an analysis with values outside the bounds in a user-defined equation or a user-modified database equation.

If the user selects the default (Cth) option for defining threshold slopes and then switches to the alternate (Fth) option, NASGRO determines appropriate Fth parameters from the Cth parameters. However, if the user selects a Cth+ value below zero, the calculated value of Fth+ is below its minimum of zero. This causes NASGRO to change all three threshold parameters (DK1f, Fth+, and Fth-) to zero. It also makes the user unable to translate the values back to Cth.

In order to resolve this issue, the minimum value of Fth+ has been decreased to -0.5. The resulting threshold values with this change are still reasonable, and the translation from Cth to Fth and back is accurate.

A summary table of NASGRO equation parameter limits is now provided in Section 2.2.4.2 of the Main Reference Manual. A button is also provided on the NASFLA material screen and on the NASMAT curve fitting screen to display this table of material parameter limits.

Graphical User Interface Improvements

The graphical user interfaces (GUIs) for a number of the NASGRO modules have been upgraded to be more flexible and dynamic. The NASFLA, NASFAD, NASSIF, NASCCS, and NASGLS modules have been converted to dynamic layouts, as has the NASGRO Launcher, the Data Migrator, and Configuration Control. This change allows dynamic resizing of the GUIs, provides a scrollbar when screen resolution is too low to fully display the GUI, and allows automatic resizing of controls for Windows Operating systems running foreign language font packs. This offers some minor support for Windows 10 DPI and font scaling controls, but this is not fully implemented at this time. While the main controls of all GUIs have been fully converted, not all of the various pop-up dialogs have been converted. Completing all pop-up dialogs over all five main GUIs and the three subsidiary ones will continue to be implemented in future releases.

New Failure Assessment Diagram Module (NASFAD)

Background

The new NASFAD module enables the NASGRO user to employ the Failure Assessment Diagram (FAD) approach[1] for assessment of crack-like flaws. This module is somewhat analogous to the existing NASSIF and NASCCS modules in NASGRO, but in "FAD space." No fatigue crack growth analysis is performed in the NASFAD module. (NASFLA has the capability to perform fatigue crack growth analyses and utilize the FAD as a failure criterion.)

The features of the NASFAD module share many of the capabilities contained in other NASGRO modules. These include geometry selection and definition, material selection, stress intensity factor and limit load calculation, and FAD plotting and output. Complete documentation of the NASFAD module is provided in Appendix L of the NASGRO Reference Manual.

Objective

The primary objective of the NASFAD module is to provide the capability to compute and plot assessment points (L_r, K_r) for known (detected or assumed) crack sizes and graphically compare them to the FAD failure assessment line (FAL). Here $K_r = K_{app}/K_{mat}$ = ratio of the applied stress intensity factor to the appropriate material fracture toughness value (such as K_c or K_{Ie}), and $L_r = P/P_L$ = ratio of the total applied load contributing to the primary stresses to the plastic limit load of the cracked structure.

The NASFAD module provides the following capabilities as options:

- Plot (L_r, K_r) assessment point(s) vs FAD failure assessment line
- Compute critical crack size (for a given load and material)
- Use API 579 Level 3/Method A or B
- Use FITNET Option 1 or 3

Applicability

For NASGRO v9.2, the crack cases listed below have FAD capability and are available in NASFAD. NASFAD has been developed such that it can easily accommodate additional FAD-enabled crack cases as they are added to NASGRO in the future.

- TC06, TC07, TC08, TC11, TC12, TC15
- CC09, CC11
- SC04, SC05, SC06, SC30, SC31
- EC04, EC05

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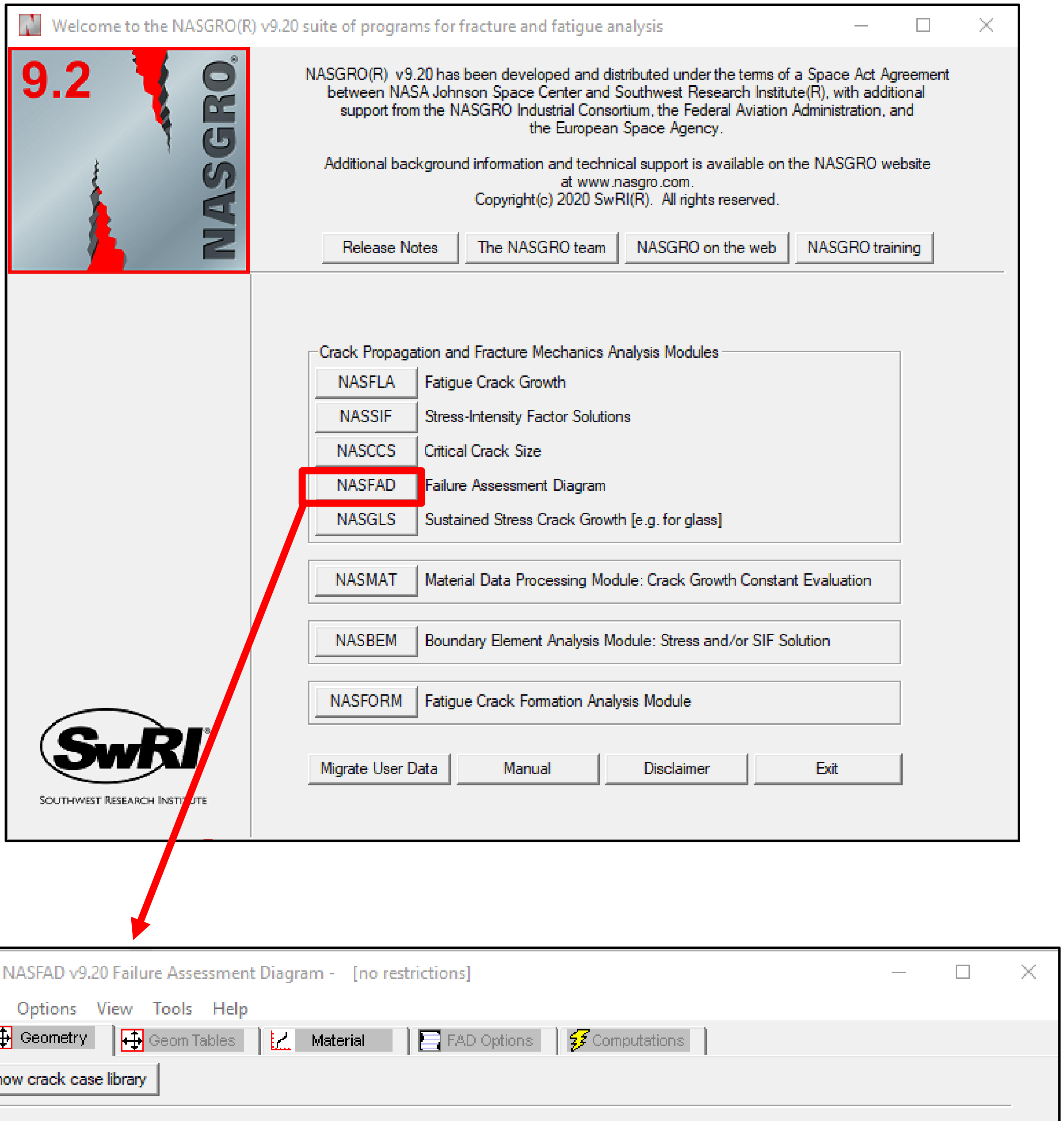
[1] Details of the FAD approach can be found elsewhere, i.e., Appendix X of the NASGRO Reference Manual, API 579-1 / ASME FFS-1, and FITNET.

Activation

The NASFAD module is activated from the main NASGRO opening screen as shown below by clicking on the NASFAD button. This, in turn, displays a set of pull-down menu items and tabs similar to other NASGRO modules. A new tab in NASFAD is the "FAD Options" tab, which initially appears grayed-out.

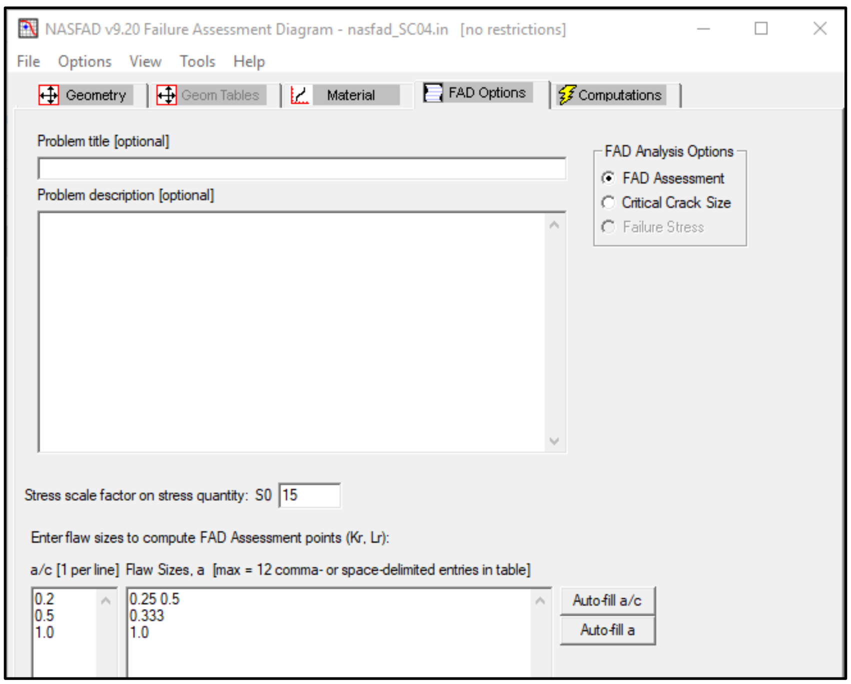


NASGRO Opening Screen Showing NASFAD Button and Initial NASFAD GUI Pull-down Option Items and Analysis Tabs

NASFAD Analysis Process and Options

The crack case selection process for NASFAD is identical to that used in all the other NASGRO modules. NASFAD allows the user to choose a material from the NASGRO material database in a similar manner as is done in NASFLA. However, since NASFAD does not perform crack growth calculations, only the material data necessary to perform a FAD assessment are displayed.

Once the geometry and material are chosen and defined, a "FAD Options" tab becomes active and the user can supply crack size information and applied stresses for use in the FAD assessment. The FAD analysis options box is displayed in the upper right corner of the "FAD Analysis Options" screen with radio buttons provided to choose between two options. The first option allows the user to plot (L_r, K_r) assessment point(s) versus the FAL; this option is referred to as the "standard" FAD assessment. It allows the user to assess whether a crack (or a set of cracks) is within the "safe" or "unsafe" side of the FAL. The second option allows the user to compute a critical crack size using the FAD failure criteria. The figure below illustrates the first option, using SC04 as an example with three different crack aspect ratios. Additional illustrations are provided in Appendix L.

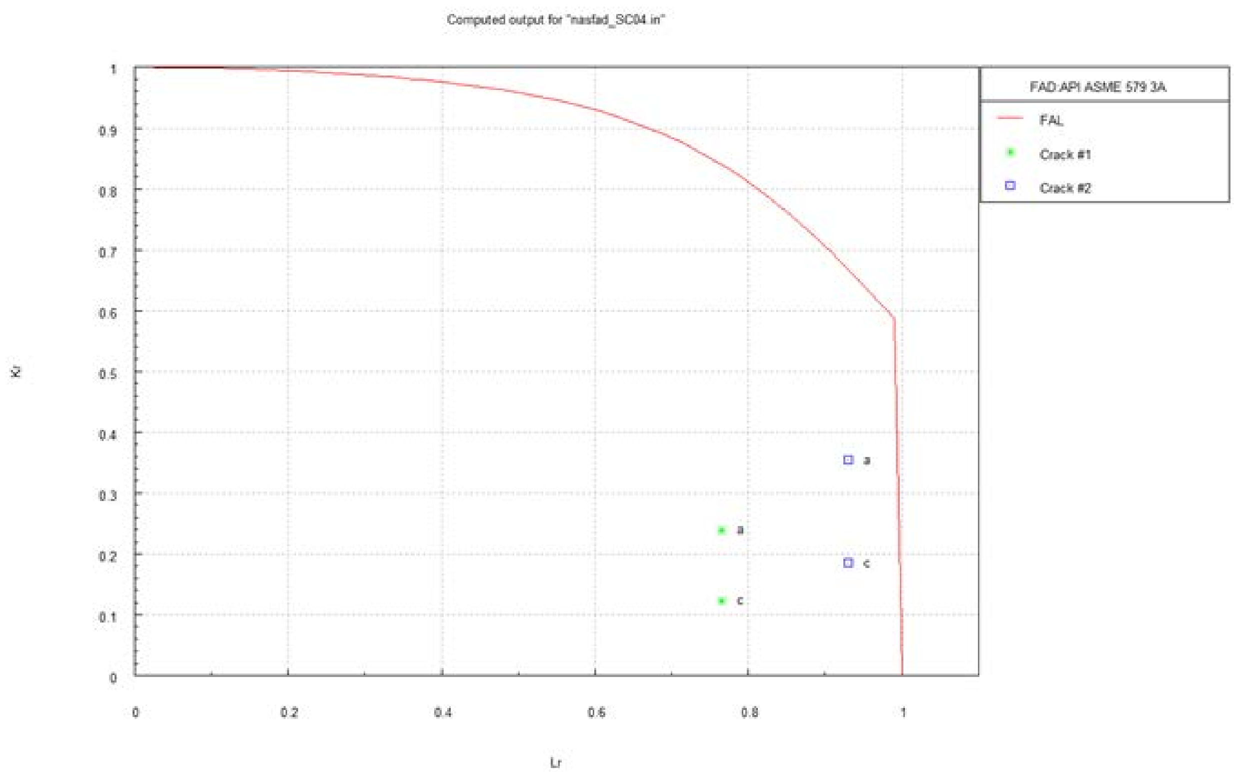


NASFAD Options Screen (FAD Assessment Option)

NASFAD Output and Results

NASFAD generates and saves an input file (*nasfad.in*) similar to what is done by other NASGRO modules. Output can be displayed by the NASFAD GUI output screen in similar fashion to the other NASGRO modules, including a button to save all the calculated results to a CSV (spreadsheet) file. The *out1* file contains NASGRO header information, problem title, an echo of the crack case and loading information, the FAD method used, and material ID and properties information.

A plot of the FAD is available from the Computations screen by clicking on the “Plot FAD” button. (The data to be plotted are obtained from the *out2* file.) This button provides the user a number of plotting options, depending on the FAD option that has been selected. Plotting choices display the pairs of calculated values (L_r , K_r) or “assessment points” computed for each crack tip of each crack versus the Failure Assessment Line. Depending on the crack case being analyzed, there could be from one to four assessment points available. A variety of options are available for plotting the results as described and illustrated in Appendix L. The figure below shows an example of the results from the “FAD Assessment” option for two SC04 cracks.



NASFAD Results Plotted from the GUI for the “FAD Assessment” Option

NASGRO v9.2a Additions, Changes and Fixes by NASGRO Module

30-Dec-19

Category	Applicable NASGRO Module: NASGRO Main	Config Control	NASFLA	NASSIF	NASCCS	NASGLS	NASMAT	NASBEM	NASFORM	Users Manual	Description
Addition			X	X	X					X	Derived the formulas for net section stress calculation for crack cases TC12, TC15, TC17, TC19, TC25, TC31, TC32 and TC37 with bending at the remote end fully or partially restrained. Implemented the net section yield (NSY) check for these crack cases.
Addition			X								Implemented the unit systems US, M2 and M3 for the ESA strip yield model
Change										X	Appendix G (Materials Tables) of the manual has been updated to include the new material IDs that were added to the database for v9.1.
Change										X	Appendix I (NASGRO Installation and System Requirements) of the manual has been updated to be consistent with the Windows 10 operating system and the recommendations for graphics settings were revised. A new setion was written revising the process for NASGRO installation in a server/client enviroment using a token-based licensing scheme. The procedures for uninstalling NASGRO were also documented in a new section.
Change										X	Appendix C (Stress Intensity Factor Formulations) of the manual has been overhauled with consistent subsectioning provided for each crack case. Currently each crack case contains at least four subsections: Overview, Geometry, Loading and Theory with pertinent details. Based on the availability of information, some crack cases also have additional sections including Optional Features, Assumptions and Restrictions, Development History, Implementation and Verification.
Fix			X	X	X	X					Crack case TC09: Previously, out of plane bending S1 was defined in terms of W, but since this geometry is an infinite plate, W is not an input parameter. This definition has been changed to remove W and also use M' (moment per unit length) instead of M, in its definition. S1 has been redefined, from: "S1 = 6M/(Wt*2)", to: "S1 = 6M'/(t*2)". (The moment notations on the diagram have also been changed to indicate that they are now moment per unit length.)
Fix			X								A typo in the text label of the polynomial coefficient grid has been corrected, from: "Coef 1,1" (which occurred twice, the second location being incorrect), to: "Coef 1,2".
Fix			X								On the Material tab, for "New Data", the on-screen field labels for "2-character alloy code" and "4-6 char form/orient/env code" were missing. This was caused by the reinitialization code that correctly cleared the associated text controls, but also incorrectly cleared these text labels. This has been corrected.
Fix			X								The log file for Spectrum editing, using the cycle counting option, did not correctly list the actual method used. In addition, it contained incorrect R-values and RMS stress values, due to internal program indexing and initialization errors.
Fix			X								When converting from Cth to Fth material parameters, the resulting values of DK1f, Fth, and Fth- were all incorrectly zero. This was due to the converter DLL not accepting a negative value for Cth. To correct this, we will now allow Cth (and also Fth) to be negative, down to a minimum value of -0.5.
Fix			X								When comparing two material IDs under unit system M3, the thickness value was not being converted to meters.
Fix			X								On the Material tab for 2D tabular material data, the grid column headers "R", "da/dN", and "dK" were erroneously cleared during a regular table reset which correctly clears the data. The source code has been adjusted to retain these column headers.
Fix			X								A false line match in the source code logic to read the material file and build selectable categories based on the data in the records caused a material file record to be processed incorrectly, resulting in that material category from that record, and that material ID in that record, to be missing from the selectable material categories in the NASFLA GUI "Show material list" dialog. This has been corrected.
Fix				X							When specifying normalization names on the OutputOptions tab, a malformed batchfile was created blocking successful computation and plotting.
Fix				X							Crack case CC12: When plotting 2D correction factors, the y-axis was not always labeled with the correct stress quantity.
Fix			X								On the 'Load Blocks' tab, when "input cycles and stresses manually" was selected for block type, inserting or deleting rows from the stress grid would not appear to function initially, but the change would not be saved when switching blocks.
Fix					X						NASCCS won't switch to secondary iteration scheme and stop with error. A check on existence of binary output database falsely terminated the computation when secondary iteration scheme was invoked. Restricting the check on the primary iteration scheme resolved this issue.
Fix			X	X							Crack cases DT04, KT04, TC33: For DT04 and KT04, the crack tips on the 'Output Options' tab were incorrectly labeled 'a' and 'c' instead of 'c' and 'c1'. Furthermore, in NASFLA, when "crack growth intervals" was selected, the "print according to" radiobox was also erroneously labeled 'a' and 'c' instead of 'c' and 'c1' and was only enabled for TC33.

NASGRO v9.2a Additions, Changes and Fixes by NASGRO Module

30-Dec-19

Category	NASGRO Main	Config Control	NASFLA	NASSIF	NASCCS	NASGLS	NASMAT	NASBEM	NASFORM	Users Manual	Description
	Applicable NASGRO Module										
Fix			X	X	X						Discrepancy in EC05 SIFs from polynomial stress option and tabular applied stress with polynomial residual stress option. The inconsistency was from incorrect origin referred by the converted stress gradient derived from polynomial residual stress.
Fix				X							Output of offset TC24 correction factors were not printed correctly. The numerical results were too large to fit into the specified format for output columns. After revision of the output format, results were printed correctly.
Fix			X	X							Incorrect call to TC24/TC14 SIF module for point spacing in connection to displacement gradients. The inconsistencies arose from incorrect usage of interface to invoke SIF routine, where the specified point spacing should be "user-specified" instead of "equally-spaced."
Fix				X							Crack case TC12: A typo in the source code caused the stress quantities on the Output Options tab for computing the stress intensity factors, to be listed incorrectly as S0, S1, instead of S0, S2.
Fix			X	X							Converted coordinates with residual stress gradient for TC30/CC23 were not consistent with the computed stress gradient from pin load. The discrepancy was from incorrect implementation of coordinate conversion for residual stress, which was required to be in connection to the computed net section width.
Fix				X							Crack case SC04: The "S0 from unit internal pressure" checkbox was not correctly checking that "Stress Intensity Factors" was selected on the Output Options tab before displaying the S0 text control on the Output Options tab.
Fix			X	X	X						Error encountered during unloading memory with SC32 crack model subject to residual stress. The error message could be found at the end of output files. The internal code to unload analysis memory from the deployment of SC32 crack model had been revised to resolve this memory allocation error.
Fix			X	X	X						Computation for SC32 crack model subjected to residual stress crashed with no result. The support for residual stress, monotonic shakedown and cyclic shakedown with SC32 was found missing. The revision included the new implementation.
Fix			X	X	X						Inconsistency from cyclic shakedown with SC32 crack model with all Kmax=0. The support for residual stress, monotonic shakedown and cyclic shakedown with SC32 was found missing. The revision included the new implementation.
Fix			X	X							When database files for CC17 were missing with long working file path, the program crashed. Additional code was implemented to prevent such overflow resulting in crashing the program.
Fix			X								When working with Walker equation data on the Material tab, the a0 value was not being saved to the input file, and would thus always load as the default value of '0.0015'.
Fix			X	X	X	X					The pop-up dialog shown when selecting "Help->About" from the main GUI menu was not properly displaying the installation directory.
Fix				X							Crack case TC16: The S0 stress definition was not being displayed or written when 'Correction Factors' was selected on the Output Options tab under the 'Chen + Schijve' bulge factor. It was also not written to the batchfile, causing an error when computation was attempted.
Fix			X	X							Error encountered even when d/L ratio was within TC16 validity limits. A tolerance issue was identified, which triggered the error. The revision resolved this invalid check.
Fix			X	X							Inconsistency in stress gradients along crack plane from pin load for CC08 crack at short and long ligament with hole nearly at the center of the plate. A previous bug fix appeared altering the result for crack in long ligament as a result of not invoking normalization factor. The fix resolved this issue.
Fix			X								When plotting 1D material data, an error message stating that the "da/dN data must be in decreasing order" was erroneously issued, when the data was already in descending order, due to blank lines being compared to each other, after the table data itself. This comparison code has been corrected to compare only the rows containing data.
Fix			X	X	X						Program to generate detailed stress files to support GUI plotting did not pick up inconsistency in stress pairs. The issue was relating to the standalone OPS program provided to GUI, not the DLLs. The program had been revised to detect stress pairs not in reference to rectangular grid and also updated to make use of x64 compiler libraries in NASGRO installation folder.
Fix				X	X						The stress scale factor controls were defaulting to blank entries instead of '0' when selecting a crack case.
Fix			X	X	X	X					GUI menu options, such as units type and the last input file load directory, were not always being correctly saved to the GUI options file. This led to the GUI resetting to the default settings irregularly.
Fix				X							Crack case SC09: Several of the geometry checks were not being performed before computation was started, allowing inputs that were outside of the geometric bounds of the crack case to be used.

NASGRO v9.2a Additions, Changes and Fixes by NASGRO Module

30-Dec-19

Category	Applicable NASGRO Module										Description
	NASGRO Main	Config Control	NASFLA	NASSIF	NASCCS	NASGLS	NASMAT	NASBEM	NASFORM	Users Manual	
Fix			X	X							Anomalous TC34 SIF variations occurred as both internal cracks grew longer. Three revisions were applied: (1) the algorithm to invoke finite plate correction was revised to remove the kink, (2) the check for solution limits included a tolerance, and (3) the incorrect reference to offset parameter in the calling interface was fixed.
Fix			X								On the 'Load Blocks' tab, when selecting 'Blocks represent flight hours', the flight hours text control was not being properly saved and updated for each block, instead being duplicated across all blocks.
Fix			X	X	X						Updating reference solutions for CC10 to be consistent with those for CC08. Comparing CC08 and CC10 results using unvariant stress uncovered some inconsistencies in reference solutions between CC08 and CC10. In this release, this had been resolved.
Fix			X								When attempting to plot multi-temperature user material files, the GUI would crash when the name of one or both of the materials was shorter than 8 characters.
Fix			X								Negative K from secondary stresses not being excluded in the determination of Kr value. The revision was deployed in this release.
Fix			X								Multiple temperature material file with load interaction model GW was not working due to a discrepancy in batch file format. The minute difference in file format for the usage of single temperature and multiple temperatures lead to this discrepancy. The revision in this release resolved this issue.
Fix			X								EC05 crack in compressive region failed the consistency check in FAD; i.e., different Lr values. The revision has been implemented to ensure consistency.
Fix			X								NASFLA GUI would crash when attempting to "Show selected details" for "sched / blk / step #" on the Computations tab, after the analysis had completed, due to an internal buffer variable issue.
Fix			X								Fixed an error in calculation of the number of cycles to user-specified crack size for crack case TC37.
Fix			X	X	X						Corrected a typo that occurred when writing the value for unit system M3 in the output file.

NASGRO v9.2b Additions, Changes and Fixes by NASGRO Module

13-Apr-20

Category	Applicable NASGRO Module										Description
	NASGRO Main	Config Control	NASFLA	NASSIF	NASCCS	NASGLS	NASMAT	NASBEM	NASFORM	Users Manual	
Change			X			X					Dynamic layout improvements have continued, further refining the "Materials" tab to provide a more readable layout, especially for Walker equation or when constant closure is selected.
Change										X	In Appendix C, the text of Section 15 was updated reflecting the new applicability of beta_R correction factor on CC09, CC11 and CC12.
Change										X	In the Manual table of contents, the titles of Appendix C and R were corrected.
Change										X	Appendix U and V were updated to include information on new SIF models.
Fix			X								The fatigue life computation in NASFLA was getting stuck for some extreme cases if the applied stress intensity factors were near the fatigue crack growth threshold.
Fix			X	X	X						Stress gradient OPS plotting problem with SC31. OPS routines to support GUI plotting were updated to be capable of handling much larger number of stress points.
Fix			X	X							Result from NASSIF analysis with SC10 crack model showing all zero values. The error resulted from incorrect assignment of computed SIF results.
Fix				X							Computed SIFs from NASSIF module with SC18 not shown in GUI's output windows. Examining the OUT1 file revealed the stress labels were missing, causing the GUI parser not to function correctly. Replacing them with correct labels resolved this data parsing error.
Fix				X							Crack case SC18: Plotting of SIF solution was not working due to an error in the scriptfile. Additionally, the GUI was attempting to plot all three tips, even for a symmetric case, resulting in no plot for the nonexistent tip.
Fix				X							Attempt to plot SIFs (correction factors) with TC24 was not generating any output. Resolving this required revisions in both GUI and DLLs to ensure consistency in data formats used by both.
Fix				X							Crack Cases TC11, TC24, TC33: The Output Options tab inadvertently enabled tip choices that were not applicable.
Fix			X								Saving 2D tabular "new data" to the user tabular data file could corrupt previous 2D records, overwriting da/dN data and adding extraneous 'junk' R-values and associated da/dN data.
Fix			X								On the 'Materials' tab, the labels for various material properties -- such as UTS -- would not display when a user 1D or 2D tabular ID was chosen.
Fix				X							Crack Case CC08: Incorrect solution limits for the long ligament were shown on the bitmap and used in GUI error checking before computation.
Fix			X								Multiple temperature NASFLA crack growth analysis terminated with an error. The scenario occurred at high R ratios when internal routines tried to populate the table. An inconsistency check was caught when comparing Kmax against Kc provided in material tables, and the computation stopped.
Fix			X								Crack case TC17: The limit "c/(W-d-r) cannot exceed 0.9" was not being properly validated, leading to the GUI rejecting some valid geometries.
Fix			X								Incorrect number of cracks shown in output for SC12 specified with two symmetric cracks. The inconsistency was found due to incorrect use of API function call.
Fix				X	X	X					Crack Case CC11: Some valid geometries would trigger the error message "a/t cannot be negative or greater than 0.95" and prevent computation.
Fix			X								On the "Geometry tab", the NDE type dropdown menu would not always display. Furthermore, selecting an NDE type could trigger an infinite loop of pop-ups that would not allow further use of the GUI.
Fix			X								Crack case CC18: An erroneous error message regarding the ratios of B/D and (W-B)/D was triggering. Updated the check to the correct ratios.
Fix			X	X							SC34 in sequential NASSIF batch runs driven through a non-conventional driver stopped after the first batch run. A memory allocation for bivariant stress across the hollow circular section was found not being released at the end of each run. Once the deallocation was implemented, the full set of multiple batch runs went through without any issues.
Fix			X								The error checking routines that confirm there are no missing entries in the Parameter Analysis grid prior to running returned errors, even though no actual errors in the data were present, which prevented the entire group of analyses from running.
Fix				X							Crack cases involving bending restraints under Tabular or Polynomial input would see the number of stress distributions change when switching between restrained and unrestrained cases.
Fix				X							Crack case CC18: Due to the unique tip configuration of c1 and c2 only, certain logical conditions within the code were not met, which prevented the GUI control "c1/c2" from the Output Options tab from being saved to, or read from, the GUI input file. Also, neither GUI control "c1/c2" nor "Flaw sizes, c1" were being written to the batchfile, preventing the analysis.
Fix			X								A GUI coding change in 9.20 alpha contained a typo, causing all F1, F2, F3, and F4 Beta factor column headers for all tips, as shown in the Computations tab output viewing window, to show as F0.

NASGRO v9.2b Additions, Changes and Fixes by NASGRO Module

	Applicable NASGRO Module										13-Apr-20
Category	NASGRO Main	Config Control	NASFLA	NASSIF	NASCCS	NASGLS	NASMAT	NASBEM	NASFORM	Users Manual	Description
Fix			X								NASFLA computational core crashed during CC18 transition to TC12. Two issues were identified: (1) one of the stress array definitions was not defined when converting the three stress gradients at remote ends for CC18 to univariant gradients for TC12, and (2) the output columns in OUT2 files with the final crack model TC12 did not print the values (instead, just "x") for crack size, Kmax, F0, F1, F2, da/dN, etc.
Fix			X								Failed consistency check for crack transition from SC30 to TC12 based on two types of bending stress definition. The issue resulted from a disabled remote stress flag during crack transition, causing incorrect stress indexing when combining SCFs with SIFs.
Fix			X								Error encountered when running CC16 NASFLA analysis with user-specified tip classes. An inconsistency was identified with the number of tip classes between pre-API and post-API interfaces.
Fix				X							NASSIF analysis for correction factors for CC18 crack model was not working. The root cause was from a flag change with crack configuration in connection to crack shape aspect ratio larger than 1.0. Once revised, the issue was resolved.

NASGRO v9.2f Additions, Changes and Fixes by NASGRO Module

6-Jul-20

Category	Applicable NASGRO Module											Description
	NASGRO Main	Config Control	NASFLA	NASFAD	NASSIF	NASCCS	NASGLS	NASMAT	NASBEM	NASFORM	Users Manual	
Addition			X									Added capability to save Beta-R values with input files, and to alert users when loaded input file is in contradiction to GUI settings for Beta-R.
Addition			X					X				Added button to "Material tab" in NASFLA and "Curvefit/Plot" tab in NASMAT to pop-up a listing of limits for the NASGRO equation parameters.
Change			X		X	X						Geometry limits were added to the following case bitmaps, where they were missing: TC01, TC02, TC03, TC05, TC09, TC13, TC16, CC01, SC09, SS01, SS02, SS04, SS05, SS06, SS07, SS12.
Change											X	Appendices G and L (material tables) were consolidated into Appendix G.
Change											X	Appendix N on Preload theory was moved into the last section of Appendix C. Appendix N is now "Reserved for Future Use."
Change			X								X	Changes made in 2-D tabular da/dN capabilities to allow crossover between da/dN vs. ΔK curves for different stress ratios.
Change											X	Revised Appendix D to document CC09-to-TC28 transition.
Change			X		X	X	X					Updated crack case selection, plot selection, batch mode file selection, and material selection dialogs to dynamic layout.
Change			X									Increased number of blocks from 40 to 100 and increased the number of possible entries for "manual block input" to 1000.
Change											X	In Appendix C, the text was updated in Section 15 to indicate the new applicability of βr correction factor.
Change											X	Added a note regarding normalization of the CC12 SIF with respect to the pseudo crack size.
Change											X	Corrected the expression of the normalized fillet radius in the SC13 Verification section.
Fix			X									2D Tabular da/dN data was being deleted from usrtbc.xml when saving new 1D or 2D user data to file. Further, using "different da/dN for each R" format was not saving correctly and would cause further overwrites of previously existing 2D da/dN data. This is an extension of the 9.2b fix.
Fix								X				NASMAT was unable to properly fit and plot data when utilizing both NASA and user data simultaneously.
Fix											X	Appendix R title was corrected in the manual Table of Contents.
Fix			X									Set the Kr value of the last point in FAL to zero. The Kr value with the last point of all FALs with Newman's TPFC, FITNET FALs and ASME/API FALs is assigned zero value in connection with the valid range of Lr.
Fix			X		X	X	X					Shifted the content in OUT1 files to the left such that the left output margin starts from the 6th column (same as the old OUT1 files).
Fix			X									Removal of an erroneous message shown in the first line of old OUT1 files generated from NASFLA. This message did not appear in the new OUT1 files.
Fix			X									When selecting multiple blocks on the "Load Blocks" tab, the "Block Summary Grid" on the "Build Schedule tab" would occasionally leave blocks empty when "manual" was selected as the block type.
Fix			X									The "suppress closure" control on the "Material" tab has been relocated to be directly under the Alpha and Smax/Flow text controls, to bring it in line with the 9.1 and earlier layouts.
Fix					X							Inclusion of a note to indicate a definition of "pseudo" crack depth that is used for normalization factor in CC12 correction factors.
Fix					X							Crack case SC30: A problem with the internal symmetric flag caused NASSIF plotting to erroneously attempt to plot data for a third tip, c1.
Fix			X	X	X	X						Crack case SC35: An internal GUI error caused plotting of F3-related data to be skipped whenever the "S3" checkbox was checked.
Fix			X									NASSIF computation for SC35 SIFs got hung up indefinitely. A numerical issue relating to tolerance for a/c close to 1.0 was identified, which requires separate formulations with a=c and a/=c.
Fix			X									Truncated material table output for da/dN vs R in OUT1 files. This issue does not show up in the old OUT1 files. The output statements have been revised to account for the increasing number of R ratios in material files.
Fix			X		X	X						Crack case CC16: Added the following GUI validation of geometric input: "0 < B < W-(D-2)".
Fix			X									Plotting Kmax or beta factor of CC18 as a function of crack size showing fluctuation. Two major issues were identified; one was relating to stress mapping for the second configuration, and the other was the designation of output crack depth/length with crack tips as well as the designated crack configuration.
Fix			X									CC12 SIF fluctuating in NASFLA computation in connection to out-of-plane bending stress. The root cause was from the definition of correction factor used to determine CC12 SIF where a small numerator could result in numerical instability. To resolve this, an alternative approach was deployed at this numerically unstable region.
Fix			X	X	X	X						Crack case SC35: This solution's upper limit for "a/D" has been changed from 0.5 to 0.49.
Fix					X							SC35 NASSIF plotting appeared hung up from a/R ratio exceeding solution limits. The program failed to catch the out-of-bound input leading to infinite loop.
Fix			X		X	X	X					Certain 'special characters' -- such as the "degree symbol" and the "Beta" symbol were not being properly displayed on some non-English Windows installations. This led to behavior such as the Beta-R menus not displaying properly or at all.

NASGRO v9.2f Additions, Changes and Fixes by NASGRO Module

6-Jul-20

	Applicable NASGRO Module											
Category	**NASGRO Main**	**Config Control**	**NASFLA**	**NASFAD**	**NASSIF**	**NASCCS**	**NASGLS**	**NASMAT**	**NASBEM**	**NASFORM**	**Users Manual**	**Description**
Fix					X							Questionable SC34 SIF variation when deploying steep gradient with S3 and a/c=0.2. The original approach for small crack depths was revised in response to the questionable behavior. In addition, one bug was identified during verification as a result of overwriting input data when multiple NASSIF analyses were stacked together and run under a single driver.
Fix			X									The computed a/c crack aspect ratio during fatigue crack growth for SC35 appeared outside the validity limits. The revision adjusted the crack depth in accordance with the validity limits in the driver such that the crack depths and SIFs in the output would be consistent. The adjustment would keep the computation going without interruption. In addition, a warning message would be printed in OUT1 and SCREEN.OUT files in connection with this adjustment.
Fix			X									The final scenario printed at the end of analysis session with SC35 NASFLA was not provided. The message was supposed to summarize the reason why the computation was terminated. The redirection after exceeding the solution limits was not captured.
Fix			X									Crack cases SC34, SC35: the "NASA std NDE" initial flaw option was intentionally not initially implemented for these new crack cases, but the radiobox itself was not disabled, so this option appeared to be live but broken. The proper settings for this option have now been implemented and it is now working correctly.
Fix			X	X	X							After an input file was loaded, for SIF Compounding, the number of defined SIF compounding tables per stress quantity/tip was always showing on-screen as one, regardless of the true number of defined tables.
Fix			X									When "elastic plastic" is selected, the "Cycles" column on the "Input cycles and stresses manually" grid on the "Load Blocks" tab was filled with checkboxes, would not allow the ability to enter the number of cycles.
Fix			X									Computation for CC11 NASFLA analysis invoking shakedown terminated with error message. An inconsistency was found when retrieving binary data information during shakedown computation.
Fix			X									Computation for SC26 NASFLA analysis with long block terminated right after transitioning into TC17. The notch designation for an ellipitical notch or a straight-edge notch was not passed to the TC17 routine after transition. The same analysis from some other NASGRO versions may work because of such un-initialization.
Fix					X							Computation for CC08 NASSIF with negative S2 hung without further response. The combined load being negative or equal to zero was the pitfall to hold the computation indefinitely when determining the crack initiation angle. The revision allows the computation to keep going if the pin load is zero with the assumption that the crack initiation angle is zero.
Fix			X									EC04 NASFLA computation without OPS enabled terminated with error during multiple stages of crack transition. The bug was uncovered when an EC04 crack transitioned through SC31, CC09 and finally to TC12. If the OPS was enabled, the computation runs to completion. The analysis failed only when OPS was disabled.