



PROCEL

INSTRUCTION MANUAL

Revision 8
(Software version 1.3.7.0)

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INTRODUCTION

PROCEL version 1.x is a tool for optimising assessments for reactive and passive steelwork protection systems. It is intended to allow a competent and qualified user to quickly set-up and analyse large number of assessment permutations. For information on the underlying calculations and assumptions inherent to the software refer to this manual.

ABOUT PROCEL VERSION 1.X

PROCEL is developed and maintained by PFP Specialists UK. Use of the software constitutes acceptance of the terms of the license agreement. It must be recognised that product assessments should be performed by a competent user and calculation software alone cannot address all the complexities and considerations present in the assessment process. The programme should always be used by a qualified professional capable of exercising sound engineering judgement. PFP Specialists UK takes no responsibility for the accuracy or use of the software.

SOFTWARE DEVELOPMENT REQUESTS AND FEEDBACK

While under license, PROCEL will be subject to regular updates. Please send all suggestions or bug reports to ian.bradley@pfpspecialists.uk with the subject as "PROCEL".

INSTALLATION AND COMPATIBILITY

PROCEL is provided in an application format (.exe) and requires Microsoft Excel version 2007 through to 2016 to be present on the computer in order to run.

Note that commercially available third party anti-virus software can prevent .exe files from functioning correctly. To prevent this please refer to the user guide of the anti-virus software, and add PROCEL as an exempted programme.

When upgrading a version of PROCEL, the user should follow the below steps:

- Remove the previous version, either by deleting or moving it to a folder such as C:\PROCEL\OLD\
- Download the new version via the link provided, saving to the C:\PROCEL folder
- Ensure the supplementary file PROCEL Assessments.xlsx is placed in the same folder as the .exe file above
- Redirect any shortcuts to the latest filename

The user can manually change the default directory listed above; note that the directory used must be in a location which does not require admin rights as default. Saved files are handled through the creation of a hidden .dat file in the PROCEL folder. A requirement for Administrator rights prevents the background creation of this file, hence preventing access to saved files.

ACTIVATION

On first execution of PROCEL the user will be required to input an activation code. The code can be obtained through clicking on the *Get Key Online* button using the hardware specific code shown in the box. Users will be required to enter the company specific username and password given to them.

Following correct entry of the password the user will be prompted to enter their hardware-specific code and their email address, and will receive an activation code.

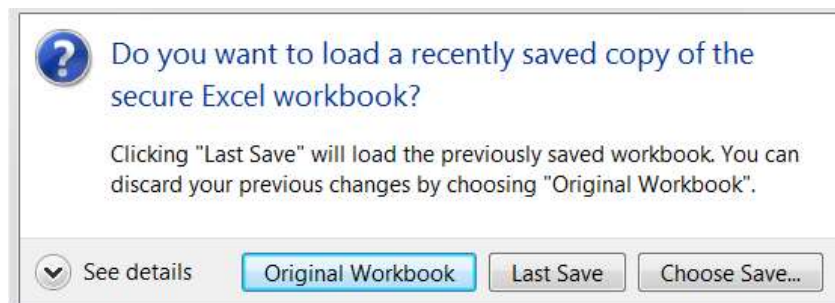
NOTE: the activation code remains valid until the end of the yearly license period, after which the user will be required to repeat the above process

SAVING SIMULATIONS

The application file can be saved in a similar manner to an excel file. Note it is not possible to overwrite the original programme, only to save duplicates. Files are saved in a .xlsc secure format and are incapable of being opened except from within the original application.

OPENING SAVED SIMULATIONS

On opening the programme the user will be presented with the following options:



Select Last Save to open the most recently saved workbook, or Choose Save to open a file dialog window and navigate to the required file.

VBE ACCESS

PROCEL has security features that prevent access to the Visual Basic Editor during operation of excel. Opening the VBE will result in automatic closure of the VBE itself, possibly causing PROCEL to stop working. Closing and re-opening PROCEL will resolve any issues caused in this manner.

SPEED OF OPERATION

PROCEL runs in an MS Excel shell and is sensitive to all factors that affect the normal operational speed of excel. Having other MS Excel applications or workbooks open at the same time greatly reduces the calculation speed and should be avoided.

GLOSSARY OF TERMS

Assessment method

The calculation methodology used by PROCEL. The type methods included are graphical and regression

Assessment package

For the purposes of PROCEL, an assessment package can be thought of as a self-contained analysis of all the assessment permutations possible on a given raw dataset. Distinction between assessment packages allows multiple analyses to be compared side-by-side.

CCT

Stands for critical core temperature, refers to an elevated temperature reached by the section. Raw data is input, and results presented, over a range of CCT values. CCT may refer to a temperature rise of absolute value, PROCEL makes no distinction between these cases.

Characteristic temperature

The average of the section average temperature and section maximum temperature. Used for the purposes of loaded (stickability) correction factors for EN13381 compliant assessments.

Criteria of Acceptability

Rules set within standards or guidance documents that define the mathematical criteria that must be complied with for an assessment to be considered valid. These are abbreviated by PROCEL to CofA 1,2,3 and 4. Refer to YB or EN13381 documents for further information.

Duration

The time taken for the section to reach a given CCT value

Permutation

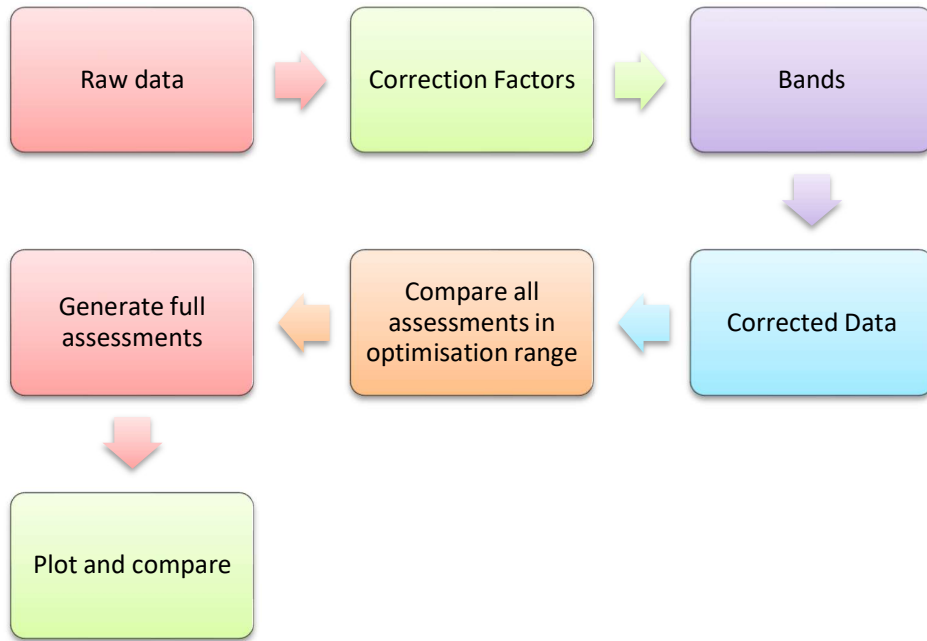
A single possible assessment outcome, relating to a specific choice of sections to be included, a particular type of assessment methodology and parameters therein (e.g. line type or regression equation), and scope of thickness, duration and CCT values included.

Section

Usually an individual test piece, however for the purposes of PROCEL this may refer to any item in the raw data table. For example, when performing an elemental assessment of webs and flanges separately, the flange results of a test piece may be entered as a section and the web results entered as an additional section under a different assessment package.

OVERVIEW

Product assessment optimisation is performed by way of the following steps:



The user interface within PROCEL is MS Excel based. Data and calculations are displayed on sheets, which users should access in the above sequence using the navigation buttons provided at the top of sheets. Sheets can also be directly accessed by clicking on the appropriate tab at the bottom. Users should not delete or insert cells, row or columns manually. PROCEL has in-built tools to edit tables and data accessed through the appropriate button.

Input sheets are locked to prevent incorrect operation by the users. The sheets can be unlocked without password; however it is recommended users avoid doing this. Results sheets are not locked, to facilitate further use of the results generated.

DATA ENTRY

The *Home* page gives two options for data entry: *Manual* and *Import from DATACEL* (DATACEL licensees only).

Manual entry

1. Resize the table to the correct number of sections and temperatures (CCTs)
2. Complete the relevant detail:
 - a. SECTION ID: completed automatically (do not change);
 - b. SECTION TYPE: used by PROCEL to determine whether a section is used for stickability correction, i.e. if it is loaded or tall
 - c. SECTION REFERENCE: the section name for primary reference by the user;
 - d. ASSESSMENT PACKAGE: assigns the section to an assessment package;
 - e. CHARAC. TEMP: sets whether the data line is characteristic (for the purposes of EN13381 correction factor calculations only);
 - f. SECTION FACTOR: the Hp/A value;
 - g. DFT: section product thickness;
 - h. TIME TO TEMP: durations to a given CCT value.
3. Modify the settings as appropriate
4. Click "Correction factors" to calculate correction factors at each CCT value

Assessments

Assessment packages are considered separately throughout PROCEL. This allows multiple assessments to be calculated and compared side-by-side

The Section Type description entered by the user has no influence on the assessment other than during the automatic correction factor calculation routine. FIRECEL assigns a section type description to each test specimen on the basis of the test standard and steel configuration. PROCEL checks the section types for ones that FIRECEL denotes as loaded (see table 1). All other section types are considered to be unloaded. If the user does not wish to spend time detailing section types they may instead use the correction factor wizard to manually identify the loaded and reference sections (see Correction Factors section).

Table 1 – Automatic Correction Factor Calculation Assumptions

Assumption	Section Type
Loaded/tall	EN LB, EN TC, EN LHC, EN LC, BS TC, BS LB, EN LC, EN LCHS, EN TCHS, EN LRHS, EN TRHS, EN LB (YB), EN THC, EN LHB, EN LCHS, EN TCHS, EN LSHS, EN TSHS, EN TRHS
Unloaded/short	All other types

Import from DATACEL

1. Filter the tests by selecting appropriate project references, test references and dates
2. Refine the sections to include by selecting/de-selecting products and section references
3. Select the type of data to import by the appropriate subsection name
4. Choose CCTs to import

- Once the table displays the appropriate sections, click "Import from DATACEL". Users will be asked whether they wish to retain existing data. YES inserts new sections below existing ones, whereas NO removes all existing data prior to inserting new sections.

NOTE: PROCEL may automatically assign an assessment name of 'beams' or 'columns' based on the orientation of the section, and set Charac. Temp to YES or NO depending on the subsection name.

Elemental Assessments
 EMTAs can be undertaken simultaneously by importing from DATACEL the Flange and Web data of the same sections. Flange and web calculations are selected through the appropriate name.

CORRECTION FACTORS

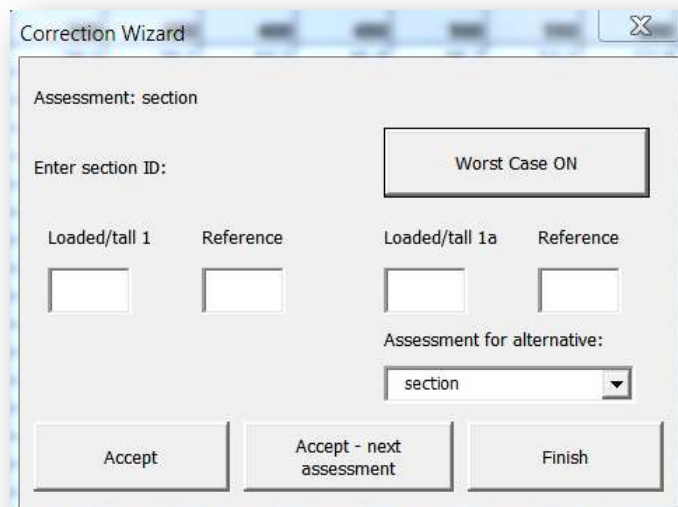
On clicking *Correction Factors*, PROCEL will attempt to calculate the correction factors automatically. This works well for simple assessments, but more complex scenarios (such as an assessment package using correction from pieces in a different package) require use of the correction factor wizard accessible from the *Correction Factors* sheet.

The automatic calculation procedure is as follows:

- detect whether characteristic data is present. If present, only characteristic sections are considered, if not present all sections are considered;
- identify loaded/tall sections (see table 1);
- locate reference sections based on a +/-10% DFT and Section Factor tolerance;
- if zero or multiple candidates are detected prompt for section ID number.

The correction factor wizard allows direct identification of any section as loaded/tall or reference through use of the section ID number in the raw data table.

When an assessment requires the use of a worst case correction, click *Worst Case* to display space for a second set of inputs. PROCEL calculates both sets of correction factors but displays only the worst case factor in the summary table.



Application of Correction Factors

One loaded/tall section	Two loaded/tall sections	Three or more loaded/tall sections
<ul style="list-style-type: none"> • Correction factor applied to all DFTs 	<ul style="list-style-type: none"> • Considered to be max. and min. DFT for correction • Min. factor used for section DFTs below min • Interpolated factors used for section DFTs between min. and max. • Max. factor used for section DFTs above max 	<ul style="list-style-type: none"> • As two loaded/tall sections but with intermediate DFTs value also used for correction • Interpolated factors used for section DFTs between min. and max.

The results of the correction factor calculation are shown on the *Correction Factors* sheet. The values can be manually over-written if required (circled in red below).

Assessment	Type	Section Type	Section Ref.	Section Factor	DFT	350	400	450	500	550	600	650
beams	Max DFT	Loaded	lb max	170.0	6.1	68.00	76.16	85.30	95.54	107.00	119.84	134.22
beams	Max DFT	Unloaded	rb max	172.0	6.2	67.00	75.71	85.55	96.67	109.24	123.44	139.49
Time adjusted for section factor and DFT						66.69	75.37	85.16	96.23	108.74	122.88	138.86
Correction Factor						1.000	1.000	1.000	0.993	0.984	0.975	0.967
beams	Min DFT	Loaded	lb min	168.0	0.3	12.00	13.44	15.05	16.86	18.88	21.15	23.69
beams	Min DFT	Unloaded	rb min	165.0	0.3	11.00	12.43	14.05	15.87	17.94	20.27	22.90
Time adjusted for section factor and DFT						11.18	12.63	14.27	16.13	18.22	20.59	23.27
Correction Factor						1.000	1.000	1.000	1.000	1.000	1.000	1.000
CORRECTION FACTORS FOR CALCULATIONS												
						Temperature						
Assessment	Item Type	Loaded/Tall	Reference	Section Factor	DFT	350	400	450	500	550	600	650
beams	Max DFT	lb max	rb max	170	6.1	1.000	1.000	1.000	0.993	0.984	0.975	0.967
beams	Min DFT	lb min	rb min	168	0.3	1.000	1.000	1.000	1.000	1.000	1.000	1.000

CALCULATE CORRECTED DATA

Bands

Band creation is relevant only to Graphical assessments.

Automatic band calculation is performed by PROCEL by *Calculate Corrected Data*. Bands can be manually reassigned by overwriting the band numbers in column *Band* and clicking *Update Bands*. PROCEL will re-assign the sections, recalculate the band DFTs, and reformat the tables.

To assist the user in determining whether the data complies with the requirements of a standard, the section factor values are assigned to section factor bands (A/V bands). Depending on the assessment standard chosen in *Settings*, three or four A/V bands will be displayed. Intermediate columns show when a section falls outside the intended bands.

NOTE: Due to the frequent use of actual measured (calculated) section factor values, the minimum and maximum bands are given a 10% tolerance.

Calculate corrected data graphical/regression

Characteristic data is never included in the corrected data table. Loaded/tall and reference sections may or may not be included, depending on the *Settings* chosen.

Clicking the relevant button will take the user directly to the *Corrected Data* table. The assessment packages are displayed sequentially, separated by a thick border.

Corrected Data
 Regression assessments correct data using only loaded correction factors ("stickability"). Graphical assessments correct data for both stickability and DFT deviation from the band DFT.

CORRECTED DATA

The corrected data table is the basis for all subsequent assessment calculations. Users should note that the DFT is replaced by the band DFT when performing a graphical assessment. Conversely, when performing a regression assessment the DFTs remain as per the original data, however the band column is assigned "-" to indicate bands are not applicable.

Users should note that it is only the information contained in the Corrected Data table that is used in an assessment. Modifications to the preceding Data, Correction Factors or Bands pages will not affect the outcome unless those changes are progressed to modify the corrected data table.

The corrected data stage allows the user to implement the advanced product development tools within PROCEL:

Include in assessment?

- Set as YES, OPTIONAL or NO
- Optional performs assessment with and without
- Allows user to determine whether sections should be taken forward to external testing

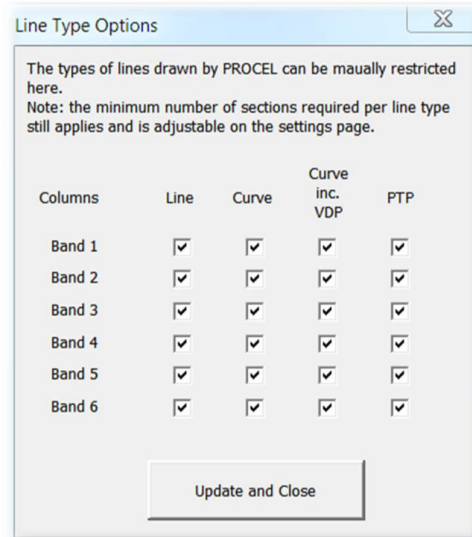
Predictive Sections

- Allows the user to add placeholder sections
- User must enter a predicted performance
- PROCEL calculates shows assessments with and without allowing user to determine whether the piece is worth testing

Line Type Options

This feature allows the user to manually restrict the line types PROCEL will draw for each band, of each assessment. It is recommended this feature be used when the number of assessment is high (>50), when it is obvious which type of line will give the best results, or when the user wishes to compare the influence of line types on a specific band.

A tick means the line type will be allowed, an unticked box means the opposite. Once complete, the user should select *Update and Close* to save changes.



If the user clicks the X in the top corner they will be asked if they want to keep the current settings. If they click *No* the form will be reset (all line types allowed)

NOTE: allowing a line type does not mean that it will necessarily be calculated. Lines are still subject to the minimum number of sections requirement, which can be altered on the *Settings* page.

Display Correction Factors

Clicking the *Display Correction Factors* button replaces the corrected DFT values with the stickability correction factor values applied to each section at each CCT (not including DFT correction for graphical method bands). Note that these values are for informative purposes and changing them has no effect.

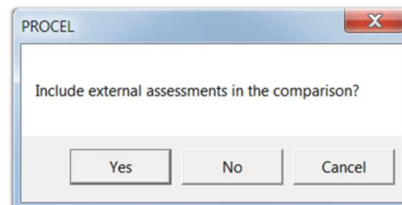
Generating Assessment Permutations

Assessments are run by clicking the *Graphical Assessment / Regression Assessment* button at the top. The status bar will display the progress of the software as it calculates each permutation of assessment at the optimisation CCT and optimisation duration specified in *Settings*.

The results are displayed on the *Graphical Permutations Results* or *Regression Permutation Results* sheets.

Including External Assessments

PROCEL v1.2.0.0 introduced the ability to include external assessments in the comparison. After initiating an assessment, the user will be prompted to include external results.



If Yes is selected PROCEL will look for a file "PROCEL Assessments.xlsx" in the same directory as the application and load the assessments present. Instruction on how to add assessments is given in the

supplementary Excel file. There is no limit on the number of external assessments that can be displayed.

PERMUTATION RESULTS

A limited quantity of data is provided for each assessment permutation result at this stage, sufficient to allow a user to determine which permutations they wish to progress without increasing computational time excessively. Results are shown with conditional formatting across the optimisation section factor value $\pm 50\text{m}^{-1}$. Red means higher DFT, green lower.

The results can be compared graphically by clicking *Results Comparison Chart*. If multiple assessment packages are used the results will be split across different charts.

Results Charts

Excel can only display 256 series on a chart, hence large numbers of permutation will be displayed across multiple charts.

At this stage every possible permutation of sections, lines types (graphical) and equations (regression) will be performed at the designated optimisation critical core temperature. If permutations exist that do not comply with assessment requirements they will be listed with error message prefixed with "N/A" given in the DFT column (see graphical section for more information).

GENERATE FULL ASSESSMENTS

Full assessments can be generated by clicking *Generate Full Assessment* and selecting the permutations of interest. Multiple permutations can be selected, across multiple assessments.

Assessments are created using a naming template that differs for graphical and regression assessments (graphical assessments are performed for individual temperatures, regressions are not). If PROCEL detects an existing assessment with the intended name it will prompt the user whether to overwrite or keep the existing assessment. If the user keeps the existing assessment, the new one will be given a number in brackets suffix. Assessments are produced in the following format:

Graphical Assessments

- Each CCT displayed on a separate sheet
- Scope of assessment given
- Modification steps to achieve Criteria of Acceptability given
- Final line equations given
- DFT table intercepts given
- DFT table given

Regression Assessments

- All CCTs displayed on one sheet
- Scope of assessment given
- Regression equation R^2 value given
- CofA modified regression constants given
- DFT tables given

RESULTS MANAGER

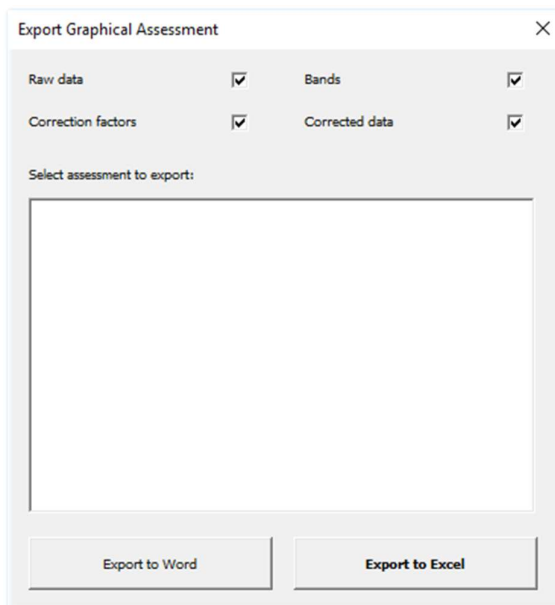
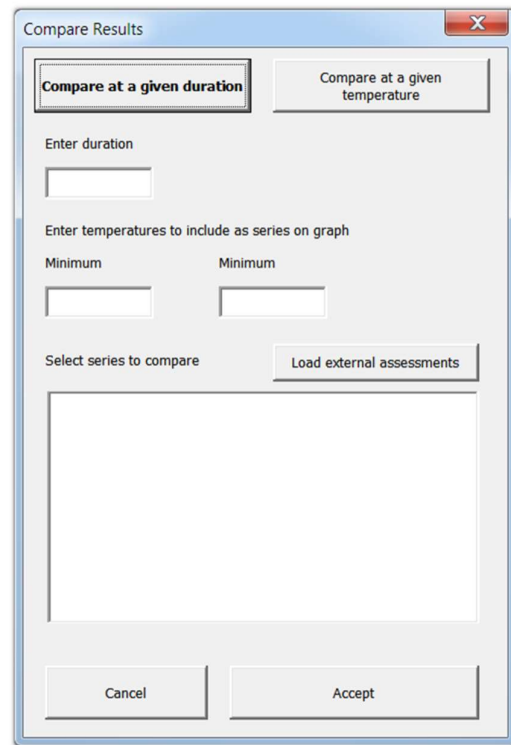
The *Results Manager* allows the user to view, compare, export (graphical only) and delete results. A list of full assessments generated is displayed along with the date and time of creation.

Comparing results allows DFTs to be plotted as a function of section factor for several assessments simultaneously.

Compare at a given duration displays the CCTs selected as different series.

Compare at a given temperature displays the durations selected as different series.

Comparison against external assessment results can be made. Clicking the button *Load external assessments* will cause PROCEL to look for a file "PROCEL Assessments.xlsx" in the same directory as the application, and load the assessments present in the list box below. There is no limit on the number of external assessments that can be displayed.



PROCEL v1.3.0.0. introduced Export of graphical assessment to MS Excel. Future versions will extend this to regression assessment and include an export to MS Word feature.

On clicking *Export Results* the user will be prompted to select a single assessment to export. Only assessment in the results manager will be available for export. All temperatures reported will automatically be exported, and the user has the option of including the raw data, the correction factors, the bands, and the corrected data.

NOTE: Users should only delete results using the Results Manager. Directly deleting sheets can cause the Results Manager to cease functioning correctly. Similarly, renaming assessment sheets will break the link with the results manager and the view/delete functions will not function correctly.

SETTINGS

The settings (or input parameters) are accessible by clicking *Settings* from various other sheets. Explanations of the various options are given below:

Assessment scope & tolerances	Apply correction factors to non-loaded pieces	Toggles correction factors on or off
	Include loaded/tall sections in assessment	Toggles inclusion of sections in the corrected data table
	Include reference sections in assessment	Toggles inclusion of sections in the corrected data table
	DFT band permitted tolerance	Sets bands size limits for automatic detection
	A/V band permitted tolerance	Sets bands size limits for automatic detection
	Maximum DFT	Loaded/tall: check the correction factors sheet for a correction factor stated as “Max DFT” for the relevant assessment. If not found reverts to highest of any. Highest of any: finds the maximum DFT of any piece within the scope of the current assessment Band DFT: uses the maximum band DFT Value: uses a value specified by the user
	Minimum DFT	Loaded/tall: check the correction factors sheet for a correction factor stated as “Min DFT” for the relevant assessment. If not found reverts to lowest of any. Lowest of any: finds the minimum DFT of any piece within the scope of the current assessment Band DFT: uses the minimum band DFT Value: uses a value specified by the user
	Maximum A/V	Highest of any: finds the maximum section factor of any piece within the scope of the current assessment Value: uses a value specified by the user
Minimum A/V	Lowest of any: finds the minimum section factor of any piece within the scope of the current assessment Value: uses a value specified by the user	
Optimisation	Optimisation point CCT	The CCT at which each initial assessment permutation will be calculated, and optimisation methods applied if applicable
	Optimisation point A/V	The A/V that optimisation methods will target, if applicable

	Optimisation point Duration	The duration at which each initial assessment permutation will be calculated, and optimisation methods applied if applicable
Reporting	Section factor interval	The section factor interval reported
	Duration min	The full assessment minimum duration reported
	Duration max	The full assessment maximum duration reported
	Duration interval	The full assessment duration interval
	CCT min	The full assessment minimum CCT reported (should be within scope of data)
	CCT max	The full assessment maximum CCT reported (should be within scope of data)
	Plot full assessment if errors	<i>No</i> omits assessment that have inflection points within the scope of the assessment. <i>Yes</i> will attempt to generate these assessment regardless. The user is recommended to save their work before switching this to yes, as some errors may cause PROCEL to fail.
	Units	<i>Mm</i> or <i>microns</i> set the units shown on the graphical method chart and the round of results to 3 or 0 decimal places respectively. <i>Mm to microns</i> and <i>microns to mm</i> will convert the DFT in the final generated assessments.
Criteria for Acceptability	CofA1	The permitted fraction by which an assessment may over predict an actual data point [(predicted-actual)/actual]
	CofA2	The permitted average over prediction across all results [(average predicted -average actual)/average actual]
	CofA3 fraction conservative	The fraction of assessment points that exceed actual data points [count of predicted>actual / total actual]
	CofA3 modification order	Toggles whether to adjust assessment lines to remove the smallest deviation or the largest deviation
	CofA3 modification order determined by	Toggles whether the smallest or largest deviation (see above setting) is determined as an absolute value or in % terms. Note absolute is the default (% can lead to CofA3 adjustment inadvertently resulting in multiple deviations being removed in a single step)
	CofA4 checks	Toggles whether to check for DFTs that decrease with increasing section factor, increasing duration or decreasing temperature (considered anomalous).

Graphical method optimisation	Optimisation bias	Initial assessment lines are drawn on a least square basis, setting this to <i>CofA1 limit</i> makes PROCEL move them to the CofA1 permitted limit it proceeds to calculate deviations and apply CofA correction
	Fix lines closest to opt. point	Toggles whether to detect the line with the greatest influence on the DFT at the optimisation A/V, and move this line last when complying with CofA criteria
	VDP source data	Sets the fire test standard from which the VDP time will be calculated for each CCT value
	VDP minutes	Allows the VDP to be fixed at a user specified point on the x-axis. Leaving this blank will use the time from fire test curve as specified above
	VDP inverse A/V	Allows the VDP to be fixed at a user specified point on the y-axis Leaving this blank will use the time from fire test curve as specified above
	Minimum sections for linear trend	Set the minimum number of valid sections present in a band for this type of line to be drawn.
	Minimum sections for parabolic trend	Sets the minimum number of valid sections present in a band for this type of line to be drawn.
	Minimum sections for ptp	Set the minimum number of valid sections present in a band for this type of line to be drawn.
	Minimum bands for valid assessment	Assessments that try various permutations of sections may encounter scenarios when a band cannot draw any type of line. This sets the minimum number of DFT bands for an assessment to be considered valid
	Ptp erroneous points	Toggles whether ptp erroneous points will be ignored or averaged with the preceding valid point (replacing both points)
	VDP line extension method	Toggles whether the VDP line is drawn to the assessment line at the inverse A/V of the lowest valid data point, or whether it is drawn directly to the lowest valid data point itself.
	Line extension limit ratio	Sets the fraction (by duration) by which lines can be extrapolated. Note: if a standard gives the extensions in terms of the target duration the fraction must be inverted (e.g. achieving 9/10 of a duration means allowing extension by 10/9).
Crossed line situations to	Set the DFT line to ignore in the event of crossed lines. Refer to Graphical Method section below for more	

	ignore	information
	Deviation calculation rounding performed	Before calc rounds the actual and predicted values to 3 decimal places (1 decimal place of a percentage) before calculating the deviations, as well as rounding the deviations to three decimal places after calculation. After calc only rounds the deviations after calculation. Typically rounding before gives a reduced number of points that fail CofA3 criteria due to very small deviations.
Regression method optimisation	Minimum mandatory CCT	Sets the lowest CCT that must be included within the assessment scope. PROCEL will try all permutations including and excluding CCTs lower than this value.
	Maximum mandatory CCT	Sets the highest CCT that must be included within the assessment scope. PROCEL will try all permutations including and excluding CCTs lower than this value.
	Use regression equations	Allows use of all three regression equations, or restricts PROCEL to the use of one or two equations.
	Allow 'split' regressions	EN equation applicable only: allows PROCEL to use any EN regression that include the optimisation CCT, down to a minimum of three CCT values.
	Apply CofA	Determines whether CofA 1,2 ,3 correction is applied to regression equations.
	CofA applied to CCTs	EN equation applicable only: <i>Individually</i> performs CofA 1,2,3 checks and modifies coefficients at each temperature values separately. Simultaneously performs CofA checks and modifies constants across all CCTs at once.
	Minimum sections to be valid	Excludes assessments with less than this number of sections (at the optimisation CCT – ignoring sections that do not have data values at higher temperatures). Prevents optional section permutations from being considered if inadequate section data is used.

GRAPHICAL METHOD

Line Types

There are four types of lines that can be drawn through the data within a graphical assessment. A least square linear trend line, a least-squares parabolic trend-line, a least squares parabolic trend line including the virtual data point, and direct interpolation between results. These four lines are given the following abbreviations within PROCEL:

- Linear
- Curve
- Curve (w.VDP)
- ptp

Valid assessments

There are two reasons why an assessment cannot be completed. First, there may be an insufficient number of bands with valid line options. In this case the permutations results page will display the following error message under the assessment number:

- N/A (bands)

The second reason is when an assessment includes a curve (of either type) that has an inflection point within the x-axis scope of existing data points. This is prohibited by the relevant guidance/standards, and the permutations results page will display the following error message under the assessment number:

- N/A (infl.)

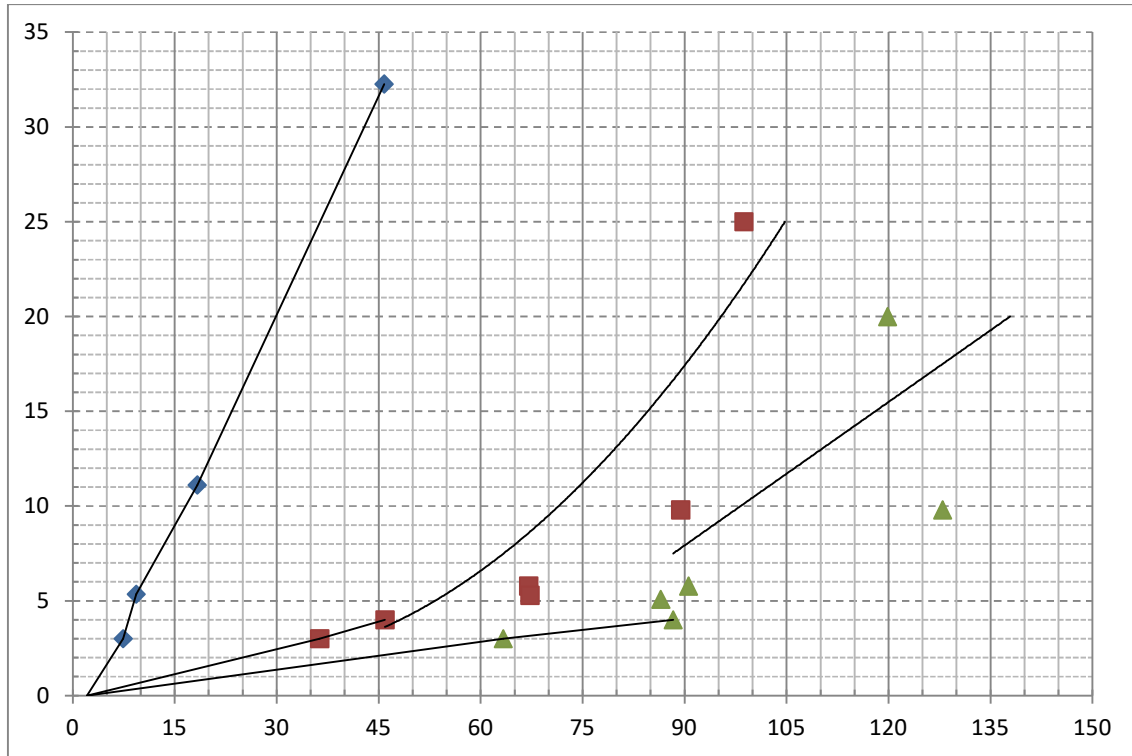
Presentation of results

To accommodate the line equations, a graph and table intercepts, each CCT value is reported on a separate sheet. The graph shows the actual data points, the CofA corrected lines, and the appropriate VDP to data lines.

Examples of anomalous results handling

The YB Graphical method may result in occurrence of numerous anomalous situations. One such instance is when a curve does not intersect with the line drawn from the VDP to the first data point or a second line to the next data point. PROCEL extrapolates the curves to the x-axis value of the second data point and transitions between the lines for the DFT table intercept points there. This can give rise to notable jumps in intercept section factors – see curves 2 and 3 on Chart 1.

Chart 1

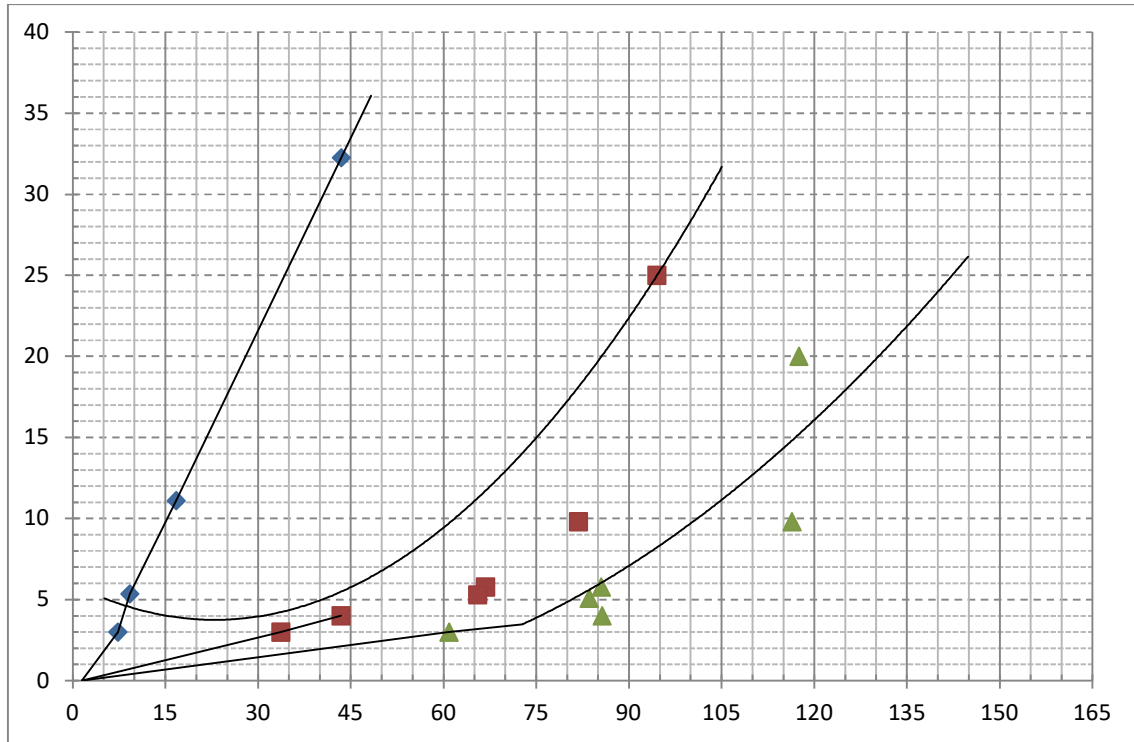


An alternative situation anomalous situation is shown in Chart 2. The curve for band two has an inflection point between the VDP and the first data point. When first drawn, the curve would intersect the second VDP line without issue. However, following curve adjustment to comply with CofA it no longer intersects the line. In this case it is not possible to calculate a percentage deviation from data point 1 using the adjusted curve as it does not cross the y axis at the appropriate value. This leads to the following questions:

- Is this point to be included within the total number of points when calculating CofA3?
- Does this point count towards CofA2 or CofA1, and if so what value should be used?

PROCEL does include the point within the CofA calculations, as to do otherwise could have a significantly harsh effect on compliance with CofA3. The deviation is assigned the value 0 for the purposes of CofA1 and CofA2 calculations.

Chart 2



PTP method issues

The yellow book point to point method gives rise to many scenarios which are not adequately defined (and which are not present in the EN method). Unfortunately, the additional guidance produced in 2016 intended to clarify how to handle anomalies at the lowest section factors inadvertently created more opportunities for unhandled anomalies and introduced subjectivity to the assessment.

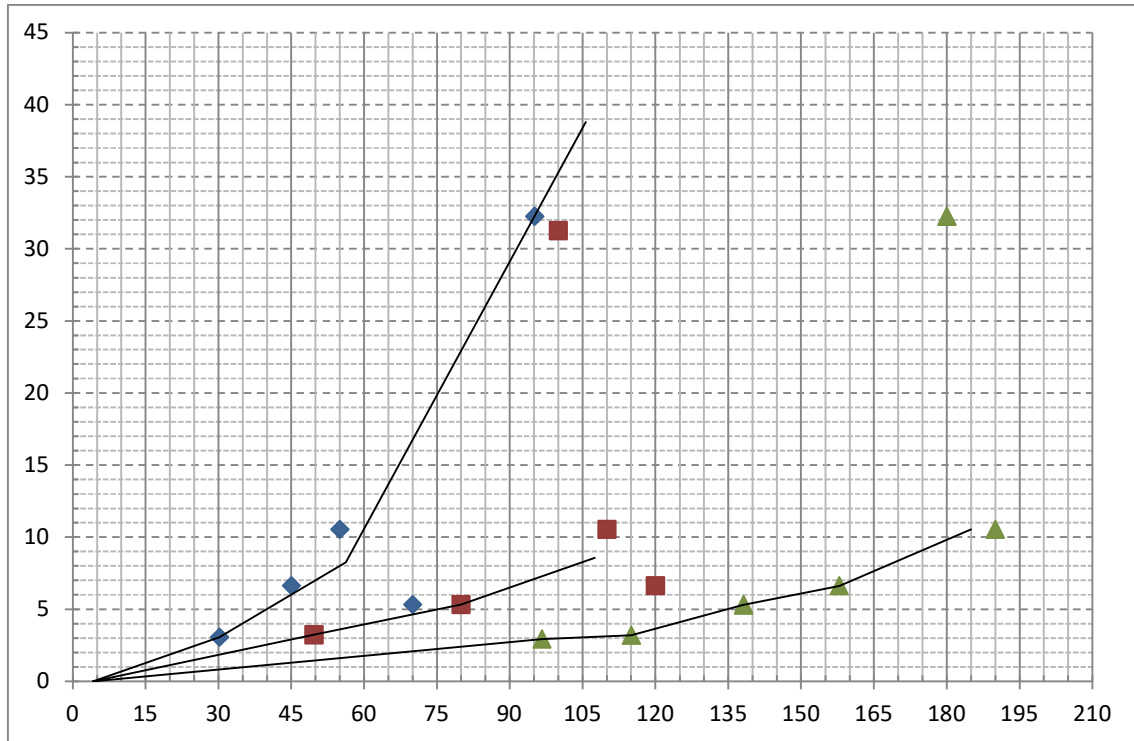
Chart 3 shows some of the possible issues and how PROCEL resolves them.

Band one has two consecutive anomalies, whereby the averaged data point has a higher predicted duration than the actual data point with the next lowest section factor. In these cases PROCEL will average the previous average with the next data point.

Bands two and three show the revised method for handling anomalies at the highest section factor, moving both durations to a mid-point. Note that the midpoint is calculated as the exact point between the durations of the two points in question, rather than the point that is 15% above and 15% below (there is a difference and there is a degree of ambiguity about which is correct). Band three shows the situation when only the lowest section factor point is anomalous. If the two sections with the next highest section factors are anomalous the averaged point will be used, not the actual data point, as shown on band two.

Users should note in this situation the line is not extrapolated forward in duration (as the last line is a vertical line).

Chart 3



NOTE: PROCEL does not move ptp lines to comply with the criteria of acceptability. In cases where the assessment is entirely point-to-point, this can lead to a YB assessment being non-compliant. There is no agreed way to move individual lines that are connected to further lines at both ends lines, as the yellow book text was written assuming a single least squares line is present. In these situations the user must decide an appropriate course of action.

Following a ptp analysis of a band, PROCEL performs a final check to ensure the duration decreases with decreasing inverse section factor. If an anomaly is found the duration will be reduced to equal that of the inverse section factor above.

DFT lines that cross anomalously

PROCEL allows the user to set whether the higher or lower of the two DFT bands is omitted from the calculations. Some additional procedures apply when the DFT band anomalies involve the highest or lowest DFT.

Chart 4 shows an example of the standard method of calculating a DFT table from duration and section intercepts taken for a given duration and CCT combination. This applies when no DFT lines cross.

Charts 5 and 6 show how PROCEL calculates DFT tables when DFT lines cross. Both charts show a situation where the bottom two DFT lines cross, intermediate DFT lines cross, and the top two DFT lines cross. Chart 5 shows the approach taken by PROCEL when the setting *Crossed DFT lines ignore*: is set to *lowest DFT*, whereas chart 6 shows the approach taken by PROCEL when the setting *Crossed DFT lines ignore*: is set to *highest DFT*

Chart 4 – DFT table calculation from intercepts without anomalies

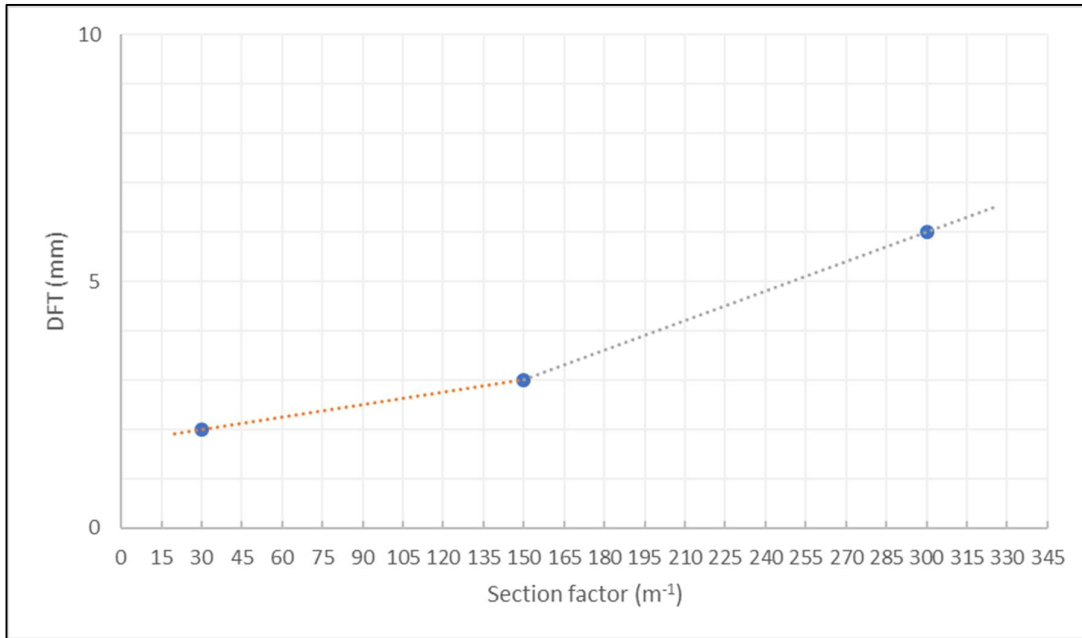


Chart 5 – DFT table calculation from intercepts with anomalies: set to ignore low DFT

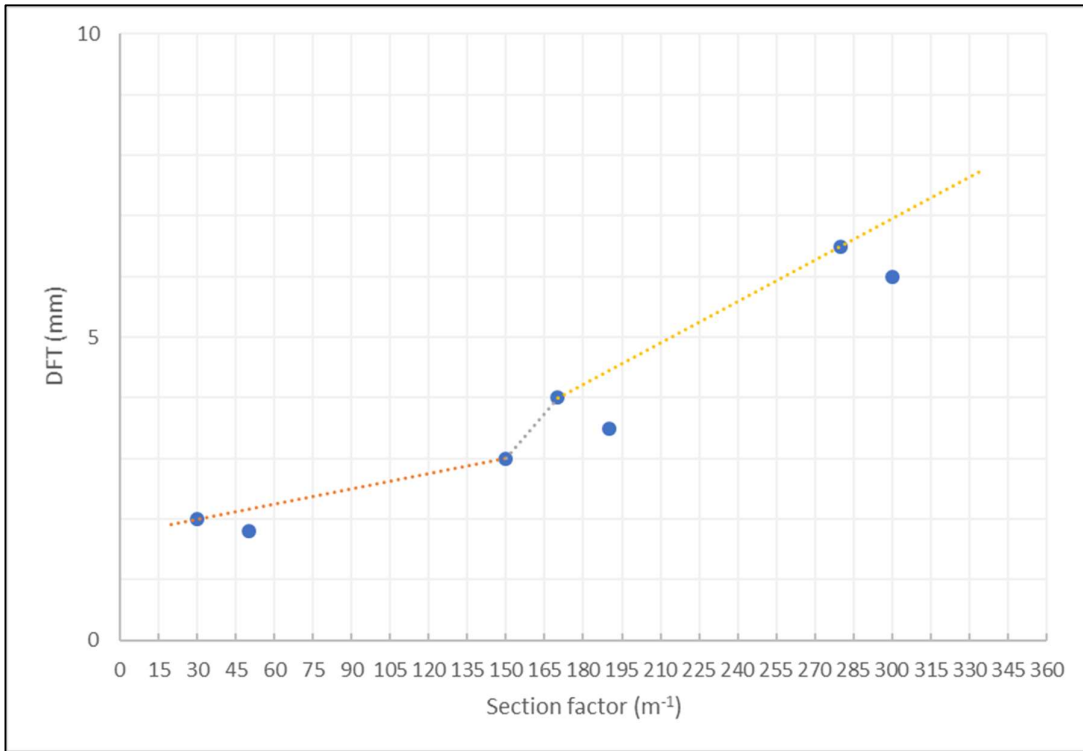
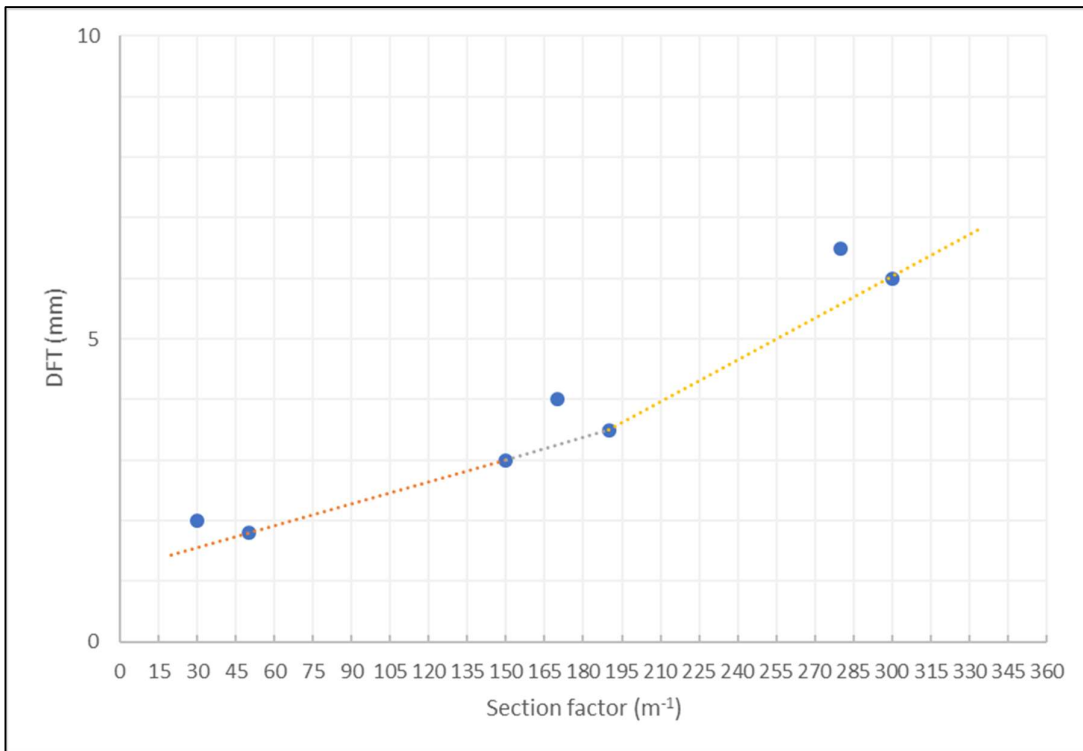
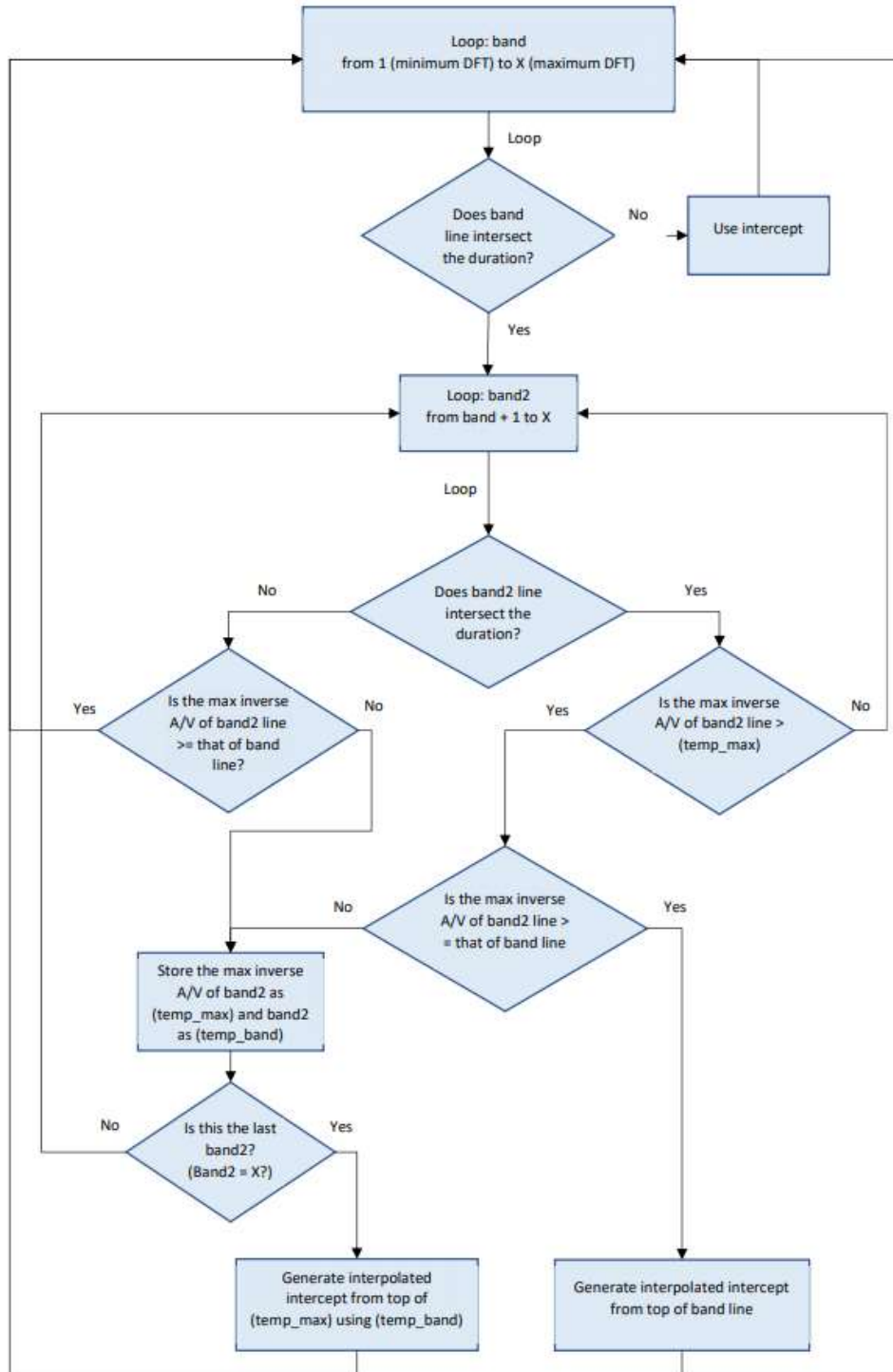


Chart 6 – DFT table calculation from intercepts with anomalies: set to ignore high DFT



Intercept procedure

EN 13381-8 permits concurrent bands to omit low-section factor intercepts. The standard does not provide a clear methodology to follow when determining intercepts (in fact the language used is optional in the standard). This can permit variations of legitimate assessment for the same data. Procel applies the following logic when determining intercepts:



REGRESSION METHOD

Equations

The three regression equations included in PROCEL can be described as follows:

$$\text{UK: } t = k_0 + k_1 \cdot \text{DFT} + k_2 \cdot \text{DFT}/(A/V)$$

$$\text{JPN: } t = k_0 + k_1 \cdot \text{DFT} + k_2 \cdot \text{DFT}/(A/V) + k_3 \cdot 1/(A/V)$$

$$\text{EN: } t = k_0 + k_1 \cdot \text{DFT} + k_2 \cdot \text{DFT}/(A/V) + k_3 \cdot 1/(A/V) + k_4 \cdot \text{CCT} + k_5 \cdot \text{CCT} \cdot \text{DFT} + k_6 \cdot \text{CCT} \cdot \text{DFT}/(A/V) + k_7 \cdot \text{CCT}/(A/V)$$

Presentation of Results

All CCT values within a regression analysis are displayed on a single sheet. Note that UK and JPN regressions are performed at each CCT value individually, and hence each CCT is displayed. The EN equation is calculated across the permutation dataset, but only shows results within the CCT values specified on the *Settings* sheet.

ROUNDING

Guidance typically specifies that deviations should be calculated based on predicted values rounded to one decimal place. It is somewhat unclear whether the actual value is also to be rounded to one decimal place. PROCEL includes the option to round both the predicted and the actual values to one decimal place before performing the calculation followed by rounding the result, or to just round the calculated result. It should be noted that when rounding of the result is performed to 1 decimal place of a percent (3 decimal places of the actual number).

An alternative method of rounding only the predicted value (not rounding the actual value) gives rise to numerous anomalous situations with regards to CofA3. Overcoming this would require adjustment of trend lines to a point more conservative than theoretically necessary. Therefore this approach is not taken by PROCEL.

CRITERIA OF ACCEPTABILITY

Automatic correction of DFT tables

The following actions are applied automatically to DFT tables:

- DFT values at section factors below the minimum permitted within the assessment scope are replaced by that at the section factor minimum
- DFT values at section factors above the maximum permitted within the assessment scope are deleted

- DFT values lower than the minimum DFT within the assessment scope are replaced by the minimum permitted
- DFT values greater than the maximum DFT permitted within the assessment scope are deleted

Criteria of Acceptability 4

COFA4 states that the product thickness should increase with increasing A/V, increasing duration and decreasing CCT. Setting *CofA4* to ON performs a check as the DFT tables are created, and takes the following actions:

- The DFT value at a given section factor is compared with that of the immediately preceding (lower) section factor value of at the same duration and CCT. If it is found to be lower, the value is replaced by the value at the lower section factor.
- The DFT value at a given section factor is compared with that of the same section factor and CCT at the immediately preceding (lower) reporting duration. If it is found to be lower, the value is replaced by the value at the lower duration.
- The DFT value at a given section factor is compared with that of the same section factor and duration at the immediately preceding (lower) CCT. If it is found to be higher, the value at the preceding CCT is highlighted in red text. Note that the value is not replaced as often this event requires a reconsideration of the assessment in general.

FURTHER INFORMATION

Please contact PFP Specialists

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