Chapter 4

Calibration

This chapter details the *Zero-Only*, *Span-Only*, and *Multi-Point* ***Calibration Adjustment*** functions and their *configuration* functions. It describes how to perform these *adjustment* functions for *single scanner modules* and *coordinated groups of scanner modules.* The chapter is similar in scope to the **Calibration** chapter in *hardware user's manuals* for NetScanner modules, but concentrates on using the Windows point-and-click facilities to accomplish all calibration tasks — instead of having to write scripts of low-level module commands. NUSS can calibrate scanner modules in any native units (e.g., psi, kPa, etc. for pressure scanners, degF, degC, or ohm(s) for temperature/resistance scanners) as long as the *module* and its *calibrator* are set to operate in the *same units*.

In this version of NUSS, only modules of the *pressure scanner* class can use all *three* of the ***Calibration Adjustment*** functions provided. Such pressure calibrations are based on one to nineteen (19) pre-specified pressure *set points* – set by a *controllable* or *external* pressure calibrator. Modules of the *temperature/resistance scanner* class can use the *Zero-Only* adjustment function – but not the other two functions. Such temperature/resistance calibrations are based on a *single* specified Zero *set point* – set by an *imaginary* (external) calibrator only.

A *controllable* calibrator is any NetScanner (Model 903x) *calibrator* module (or any System 8400 PCU module for *Advanced* users) over which NUSS has direct control. An *external* calibrator is one over which NUSS has no direct software control, and that the user must manually-manipulate by external means in order to stimulate the transducers to be calibrated. When an *external* calibrator is used, NUSS prompts the operator to set pre-specified points with that calibrator in units specified by the calibrator's range. The operator then manually enters the exact (external) reading from the calibrator after each setting – when NUSS asks for it. Such an *external* calibrator can be *imaginary* (e.g., does not exist) or *real* (e.g., a laboratory dead-weight tester) as long as the transducers get stimulated correctly, and the resultant exact readings are given to NUSS correctly.

NetScanner modules of the *calibrator* or *standard* class are secondary standards – and are **not** calibrated by NUSS. These modules are generally returned to the factory for any major calibration adjustment. Minor *Zero-Only* adjustment is automatically performed on *calibrators* (by NUSS) when they are used to set differential pressure set points for a *scanner's* calibration adjustment session. PSI makes other software packages available to customers for calibrating these precise *calibrator* and *standard* modules – with suitable laboratory standards.

4.1 Introduction to the LRN

Calibration Adjustment of *scanner* modules requires two basic configuration tasks be accomplished ahead of time. Then, when an *adjustment* is required, the process proceeds almost automatically – for either single-modules or groups of modules. Both configuration tasks focus on something called a **Logical Range Number (LRN)**. There are eight (8) unique LRNs defined by NUSS (numbered 1-8). An LRN is just a configurable *intermediary* that may represent any one unique physical transducer range (with specified units) and a group of one or more set points that cover that range. The set point(s) must be able to be set by the assigned calibrator.

The first configuration task associates a unique **LRN** with *each similarly-ranged transducer* (channel) of *each module* to be *adjusted* (see ***'Calibrate | Associated LRNs'*** item on a single-module *context* menu – or on the home-base *group* menu). In some modules you can set appropriate pneumatic valves that is used for stimulating each transducer (channel) when the adjustment is started.

The second configuration task associates each utilized LRN with a particular *calibrator* (*controllable* or *external*), and a pre-specified group of precise *set points* that calibrator sets in a specified order when the adjustment is started (see ***'Configure | Calibrators (NUSS)'*** on home-base menu only). An one LRN needs to specify either the *full-range* (or a *sub-range*) of its calibrator and the *measurement units* for its set points. Any LRN used to calibrate a *pressure* scanner may also need to specify a pressure mode (*absolute* or *differential*). These extra parameters must match the particular transducer(s) or channel(s) or sensor(s) to be calibrated. You may assign the same *calibrator* to more than one LRN, since each LRN is utilized sequentially within an automatic *calibration adjustment* session.

After both LRN configuration tasks are completed, you must have assigned all *like-ranged* scanner module transducers to an appropriate LRN. Each LRN used has also identified which *calibrator* stimulates its particular transducers, across their entire range of use, with pre-specified *set points*. For *pressure* calibration adjustments, set points must also be specified in the appropriate *differential* or *absolute* mode. For all scanners the *native units* of both the calibrator and the associated scanner's channels to be calibrated must match. An LRN assigned to an External calibrator may also be assigned to a single *Zero temperature* or *resistance* set point – for calibrating *temperature*/resistance scanners (Model 9x46).

A *temperature/resistance* scanner can only have a single one-point adjustment (see ***'Calibrate | Zero-Only'*** for more information). Multiple pre-assigned LRNs may be adjusted together (though sequentially) during each subsequent ***Calibration Adjustment*** session of a *particular type* for *pressure* scanners (see menu items ***'Calibrate | Zero-Only'***,

or ***'Calibrate | Span-Only'*** or ***Calibrate | Multi-Point'***). In either case, a session may be initiated for a single-module – or for a group of scanner modules. All or part of this central LRN configuration concept is also useful to several other ***Test*** functions of NUSS as well. In particular, see the ***'Test | Leaks'*** and ***'Test | Pressure Accuracy'*** menu selections described in **Chapter 5** which both heavily utilize the LRN.

NOTICE: NUSS can *adjust* the "offset" (zero), "slope" (gain), and "multi-point" calibration coefficients of transducers of *pressure* scanner modules – **but only if those modules and their calibrators have been set to use the same native pressure units** (e.g., **psi**, **kPa**). In other words, the ***UnitsX*** module option (see ***'Configure | Other Options'***) must be set to **the same value for both the calibrator and the calibrated module**. Absolute set points have an **'A'** added to the units name (e.g., **psiA**, **kPaA**).

4.1.1 Configuration Requirements to Calibrate Scanner Modules

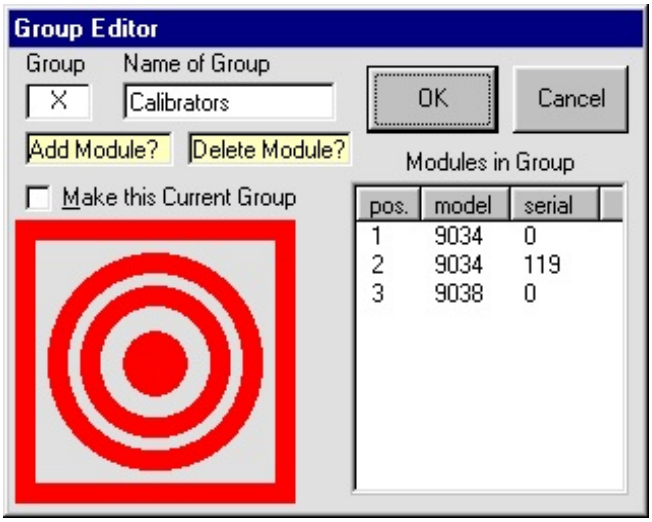
As summarized above, you can perform ***Calibration Adjustment*** functions only if two basic configuration tasks are completed ahead of time. Actually we oversimplified this process a bit, as there is actually a third (but normally automatic) task: the definition of **Group X,** that defines all the calibrators recognized by your NUSS system. This added task is really a pre-requisite to one of the other two – but all three configuration tasks are discussed in detail below. The automatic configuration of **Group X** (described in **Sections 4.1.1.1**) must be accomplished first. Then, the other two manual configuration tasks (described in **Sections 4.1.1.2** and **4.1.1.3**) may be performed in any order, as long as the proper LRN associations are complete and correct before any *adjustment* function is executed for affected module(s).

Once an LRN is fully defined, it can be utilized in a ***Calibrate Adjustment*** session (and can also be used by other ***Test*** functions described in **Chapter 5**). Actually, the program (form) that carries out the ***Calibrate Adjustment*** session (or ***Test*** session) searches for and identifies all completed LRN associations defined, and offers to test all of them (sequentially) — or only the ones you select.

4.1.1.1 Group X Definition

All modules recognized as *real pressure calibrators* are automatically defined in **Group X**, soon after NUSS starts (and has completed its first ***Query*** of all system modules present on the network). After this, you may view (and possibly edit) **Group X** with the **Group Editor** obtained by selecting the ***Group*** menu item on the main menu of the **Network Status** form. However, any manual editing of **Group X** is lost the next time NUSS restarts, as it has been re-created by this restart. *External* calibrators may be *real* (e.g., a laboratory dead-weight pressure calibrator) or *imaginary* (e.g., a temperature or resistance calibrator), but these are not defined in **Group X**.

Whenever a *real pressure calibrator* module is added to (or taken away from) your system you must remember to restart NUSS (or manually update **Group X**) to insure that **Group X** contains all the *calibrator* modules on your network. Because of the "potentially unreliable" character of the UDP ***Query*** process that recognizes modules on the network, you may occasionally "miss" a calibrator module being included in **Group X**. If that happens frequently, then you need to configure all your modules with a unique *back-off delay* to avoid Ethernet collisions on the network. When it happens, you can either restart NUSS again – or manually add any missing module to **Group X** – after repeated *manual* ***Query*** operations eventually finds it. To verify success, click the ***Groups*** menu item from the **Network Status** form's menu. This pops-up the ***Group Editor*** form (see example below), which allows any Module Group (including X) to be viewed and temporarily changed by simple drag and drop methods.



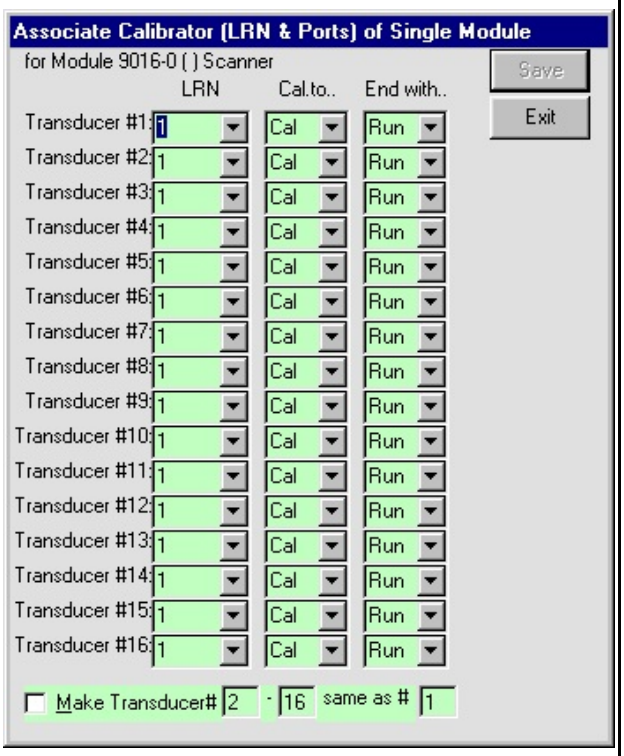
Group Editor showing a typical **Group X**

You must first select **Group X** by clicking the **Group** *text box* (upper left), then choose an available group on a pop-up form. To add a new *calibrator* module to **Group X**, drag its

(pre-highlighted) serial # icon from the **Network Status** form's **Nodes Map** to the red target box on the editor's form, and then drop it. To delete a calibrator module, click (and highlight) its number (under the **pos.** column of the **Modules In Group** list), then drag the highlighted number to the target (of simply press the <Delete> key).
For more information on the methods (and limitations and peculiarities) of using of the **Group Editor**, see **Section 3.2.1** in **Chapter 3**. For this dedicated **Group X**, NUSS only allows modules of the *Calibrator* class to be assigned to it.

4.1.1.2 LRN-to-Transducer Associations For Scanners

You must configure all *LRN-to-transducer* associations for *each individual transducer* of *each scanner module* to be adjusted. At the same time you must specify any *"pneumatic"* valves to be set by NUSS directly – both during and after the particular LRN's calibration adjustment procedure – **for modules that have valves** (otherwise set None). In some cases, you may specify valves for pressure scanners which have no real valves (e.g., Model 902x), in order to suppress certain prompts. Since it can be viewed as both a *calibration* and *configuration* function, this calibration association function ('***Calibrate | Associate LRN(s)'***) also appears on the *configure* menus ('***Configure | Associate LRN(s)'***). The example (see inset right) shows the default form – displayed after it is selected via the *context* menu for a single 9116 pressure scanner module, but before any editing changes have been made.



Associate LRN's form for a single-module

This form may seem unnecessarily complicated, but is that way only because scanner modules can have transducers with dissimilar ranges. In particular, Model 9022, or 9x46 modules – where each channel can easily change to a different range with a simple plug in of a new transducer – the flexibility to assign different LRN's to different channels is an obvious requirement. A check box at the bottom of the form simplifies the configuration process (for modules with identical or different ranges) for all channels or contiguous groups of channels. It allows any LRN and Valve assignments made for a particular

Transducer (default #1) to be copied to any contiguous range of other transducers (default #2 though module's highest #) on the form.

The form above, upon first examination, would also appear to allow each transducer to independently specify a different automatic valve to set when starting the Calibration Adjustment function (see "Cal-to" column), and to have yet another (different) valve set when that procedure is done (see "End-with" column). This is not the case however. Normally, the Cal valve is selected in the first of these columns, and the Run valve is selected in the other. However, if you change any one of these valve settings, all of them (that use the same LRN) also changes together. This is an absolute requirement of the adjustment function (i.e., all transducers calibrated with a particular LRN must use the same valve position to calibrate it, and must set the same (but possibly another) valve position when finished). However, when you have a multi-range module (i.e., one with more than one transducer range installed in it) you may have to always perform automatic calibration through the separate Run ports (rather than through the manifold Cal port) to avoid over-ranging the most sensitive transducers when the less sensitive ones are calibrated. In this case the Run valve position would be specified in both columns. For modules without any automatic valves to set (e.g., a Model 9022, or 9x46) or any module with non-functioning valves, there is a None choice that may be specified in both valve columns. This choice causes the adjustment function to skip setting that valve, and instead prompt the user — asking him/her to manually enable any necessary external pneumatic circuit (at any point in which NUSS would have automatically set a valve's state). However, since NUSS knows that Model 9022 has no valves – you can specify the "imaginary" valve names anyway (instead of None) to cause the manual prompts to also be skipped. In such cases, however, the necessary pneumatic plumbing (for 9022 only) must be properly connected to assure that each set pressure stimulates its transducers. For Model 9x46 temperature/resistance scanners, which also have no valves or pneumatic circuits, it is best to always specify *None* in the valve fields of this form. This is because prompts are usually required for these modules to accomplish some special modes of Zero-Only adjustment.

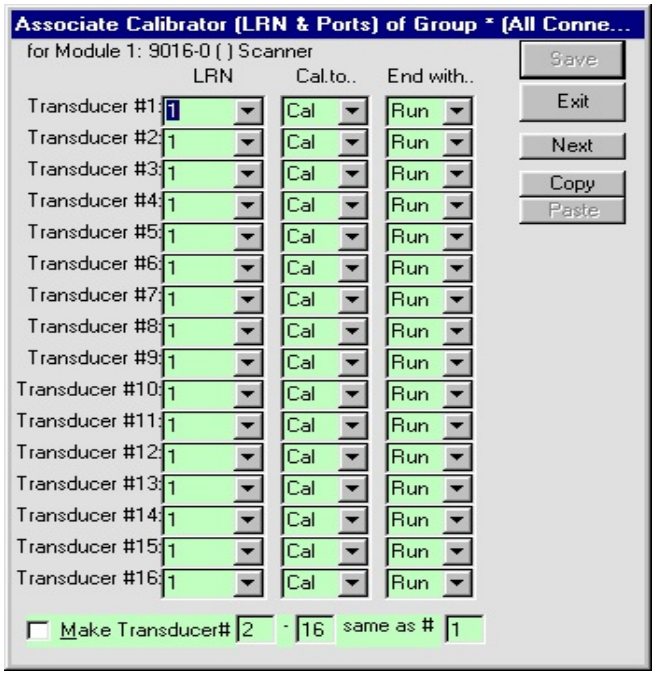
Now, return to the example form shown above. The current LRN association of any transducer (which indirectly assigns the particular calibrator module that stimulates it) is selected by clicking the arrow at right end of a list box. A drop-down list then appears showing each available ***Logical Range Number (LRN)*** 1 through 8 plus a ***None*** choice. Click the ***None*** choice if that transducer does **not** take part in any ***Calibration Adjustment*** function, or click a suitable LRN in the list (that is associated with an *automatic (e.g. Model 903x)* or *External* calibrator).

If most or all of the module's transducer's are assigned the same LRN and valve assignments, then it is quicker to click the *check box* at the bottom of the form. This transfers your LRN choice (and both valve selection choices) for transducer #1 — to all (or

selected) other transducers on the form. If none of the assignments are contiguous, you must separately associate each transducer's LRN and valve settings.

NUSS has a standard way of indicating all edit changes on a form. A changeable field has a *light-green* background color (meaning: *you may change me*), but changes to *dark-pink* (meaning: *you have changed me*) when you edit it. After making any changes on this form, the **[Save]** button is also enabled. Clicking it saves the changes to an internal file. It then re-reads the file and re-displays the final results for your review. You then click the **[Exit]** button to leave the form. If you click **[Exit]** without having saved any previous changes first, you are warned and allowed to save if desired.

The ***Associate LRNs*** form also has a ***Group*** version, with added buttons, that may be selected from the *home-base* menu (see inset right). This *group calibration* setup function ('***Calibrate | Associate LRN(s) (Group's Scanners)'***) also appears on the home-base *configure* menu ('***Configure | Associate LRN(s) (Group's Scanners)'***). With this form you can view each of the modules in the group, *sequentially*, by pressing the **[Next]** button. The next module's data appears, and its <*modid*> appears at the top of the form (just below its title). You can edit any one or all of these modules, saving the results for the current module — before you move to the next. The **[Next]** button warns you if you have made any changes to the current module without saving them with the **[Save]** button first.



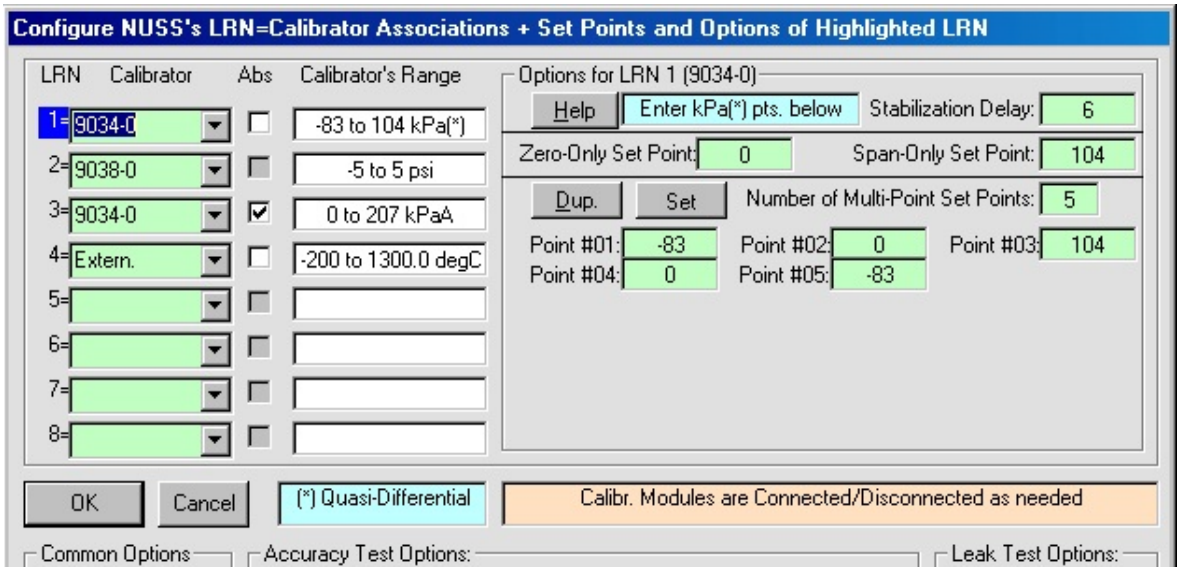
Associate LRNs form selected from home-base menu

You may also use this form to edit one of the modules in the group and then copy it's data to other modules in the group. This is useful if you have several identical modules in the group that need to be identically configured. Click the **[Copy]** button to copy the data from any currently viewed module (edited or not) into a scratchpad. Then, press **[Next]** to view any like module in the group. Click the **[Paste]** button to paste (and then save) the scratchpad's contents, thus replacing the data of the currently displayed module with another's data.

After using the above forms to set LRN associations, you may determine, on the ***Run*** form of any scanner module, if any of its channels has an LRN assigned, by observing the ToolTip of its *measurement name* label (left of channel's EU Datum field). For calibrator modules, its ***Run*** form Title Bar shows all LRNs (in parentheses) to which it is assigned.

4.1.1.3 LRN-to-Calibrator Associations and Set Point Specification

The home-base menu item '***Configure | Calibrators (NUSS)'*** displays the following form (only the top of the form is discussed below). It allows any of the *real pressure* Calibrator modules available in your system (and pre-defined in **Group X**) to be associated with any **Logical Range Number** (1-8). Review **Section 4.1** in this chapter for the purpose of an LRN.



Top of the ***'Configure | Calibrators (NUSS)'*** form

Consider the purpose of the spreadsheet-like collections of controls on the left side of this form and adjacent **"Help"** frame on the right side of this form. Several *Test* and *Common Options* on the bottom of the form are not shown and are discussed later. The **LRN** *column* (extreme left) can have any *row* clicked to select and highlight one LRN (a bright blue highlight marks the selected one). This causes only that selected LRN to display its list of *set points* and other adjustment *options* in the frame labeled **Options for LRN <x> (<calibratorname>)** on the top right of the form. Note that you may also click any control in the columns labeled **Calibrator** or **Abs** or **Calibrator's Range** to change the highlighted LRN selection.

Facts About Example Form Above

LRN #1 is selected (highlighted bright blue). It is assigned to a *pressure* calibrator (9034-0) which was set to operate in **kPa** pressure units (by changing the module's **Units_X** multiplier with the ***'Configure | Other Options'*** form). This calibrator's *differential* mode is selected (**Abs** check box *unchecked*) for use at calibration adjustment time. The unselected **LRN #3** is assigned to the *same calibrator*, but set to operate in its *absolute* (**Abs** checked) mode at calibration time. The unselected **LRN #2** is assigned to a *differential-only pressure* calibrator (its **Abs** box is grayed out), and is set to operate in the default *psi* units. Finally, unselected **LRN #4** is assigned to an *Extern* (external) calibrator. Its **Calibrator's Range** column has been *manually-edited* to specify a *temperature* range – for use in Zero-adjusting selected *thermal* channels of a **Model 9x46** *temperature/resistance* scanner. Using such *temperature/resistance* scanners is deferred to **Section 4.1.1.4**. The following discussion in this section is limited to just *pressure* scanners. **Please note that you should only change a *pressure* calibrator's units by changing its Units_X value, not by manually-editing its Calibrator's Range as is done routinely for a *Extern* calibrators.**

The calibrator you assign to each LRN on the form eventually stimulates specific channels of other *scanner* modules you specified in the previous Section (4.1.1.2) for that same LRN. For *pressure* scanners all the currently known *real pressure calibrators* are listed in each of the eight *list boxes* in a *column* labeled **Calibrator**. You only need to select one to assign it to the highlighted LRN. Calibration pressure set points (and other options) must also be specified for each assigned LRN, and a **[Help]** button assists you in doing this (described later below).

To assign a particular pressure calibrator to an LRN, click the arrow (at right edge of the corresponding LRN's *list box* in the **Calibrator** column). This reveals a drop-down list of all *calibrator* module choices (i.e., all the modules assigned to **Group X,** plus an extra **Extern.** choice). Click the desired choice to associate that *calibrator* with its LRN. The **Extern.** choice assigns an *unspecified* External (real or imaginary) calibrator. For example, this might be a *real* laboratory dead-weight tester for stimulating pressure scanners – a calibrator that cannot be controlled directly by NUSS sending it commands.

Note (in example above) that the same calibrator may be assigned to more than one LRN on this form. This is useful since different calibration *set points* might need to be defined appropriately for different uses of a particular calibrator (e.g, as when a calibrator uses only a subset of its true range to calibrate more sensitive pressure scanner transducers). This is

particularly useful if you do not have a unique calibrator matching every possible full-scale transducer range. Since each selected LRN is adjusted *sequentially* within one automatic session, such calibrator re-use is possible during a session.

The check box controls in the narrow **Abs** column may be *checked* or *unchecked* to specify a desired pressure mode (differential by default when a new assignment is made). If the assigned calibrator is one only capable of differential operation, then its check box remains dim and unchecked. If it can operate in the absolute mode, the check box is enabled to allow the user to select the mode of the calibrator – for when it is used to stimulate appropriate pressure scanner transducers during the adjustment session. An **Extern.** calibrator is always assumed to be able to set absolute or differential mode set points, but its *units name* (4th symbolic token in the Calibrator's Range text box) must be set to reflect the *mode* you expect to use (see next paragraph).

The text box controls in the **Calibrator's Range** column show the range (or editable sub-range) and native units (psi, kPa, psiA, kPaA, etc.) of each calibrator assigned to the associated LRN. When a new assignment is made, the selected calibrator (if not Extern.) may be connected and queried immediately to find and then display the full range of that calibrator. For an *absolute* calibrator, only its *quasi-differential* range is shown by default (marked with an asterisk (*) as footnoted in a *light-blue* status box at the bottom of this column of controls). Though this text box is editable, it must maintain the 4-token string format shown. Also, you must NOT change a real selected pressure calibrator's pressure units or pressure mode by changing the 4th token manually.

Notice that the **Options for LRN #** frame, on the top right side of the form, displays the calibration pressure set points for **only the single selected LRN** (LRN #1 in example above). To see any one of the other seven LRNs' options, you must first *highlight* that LRN as outlined above. This **Options for LRN #** *frame*, once selected to display a particular LRN, allows the user to enter (or edit) all the *calibration set points,* and other LRN-specific *calibration adjustment options*, to be used when that LRN and its assigned *calibrator* module participates in an ***adjustment*** or ***test*** session. Since all these options are specified here in advance, operation is quite automatic later, and requires little operator assistance except for exceptional conditions (e.g., as when you are using an unspecified External calibrator, or you are adjusting a Model 9022 scanner module which has no automatic valves that NUSS can control). NUSS *prompts* in these situations (i.e, stall the process, display what it expects in a blinking text box, and have the operator confirm that he/she did it, by clicking a **[Resume]** button)

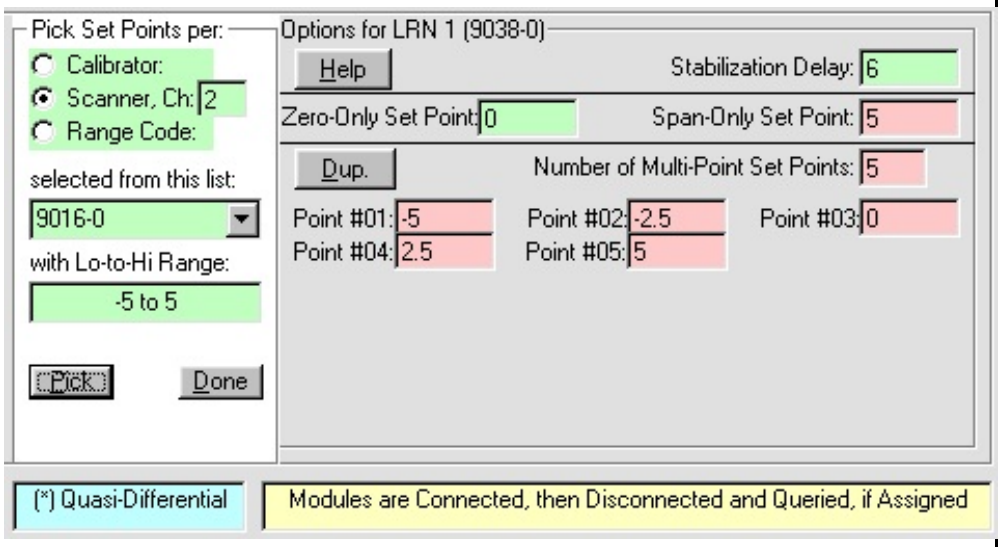
When assigning calibration *set points* to a particular LRN, first be sure that the frame's label matches the particular LRN you wish to set points for. Enter a **Stabilization Delay** (time in seconds NUSS waits, after that calibrator sets a particular set point, before an

accurate reading is to be made from that calibrator) if the default (six (6) seconds) is not sufficient. Note that in NUSS Version 1.2.17, and thereafter, an *additional delay time*, up to 40 seconds total, may be added *automatically* by the **Calibration Adjust** or **Pressure Accuracy Test** programs to account for temperature effects when high pressure set points (>100 psi or equivalent other native units) are set.

Next, enter the **Zero-Only** calibration point (presumably zero or some pressure you wish to read zero), and the **Span-Only** calibration point (presumably the full-scale range of the target scanner transducer(s)). You should enter these two values even if you only plan to use the Multi-Point adjustment function, as they help defined suitable defaults for **Multi-Point** (see below). The **Span-Only** set point is also used by a ***Leak Check*** test function. Finally, if you do use the Multi-Point adjustment function, be sure enter the *number* of **Multi-Point** calibration points, and enter the values of each of these set points manually – or use the **[Help]** feature described below..

When you first assign a new calibrator to an LRN, three (3) **Multi-Point** set points are created by default, based on the full-scale range of the *calibrator*. Since a calibrator may stimulate scanner transducers of lower range using a sub-range, such defaults are not always suitable, and may be changed manually or by a factory set point selection method described below.

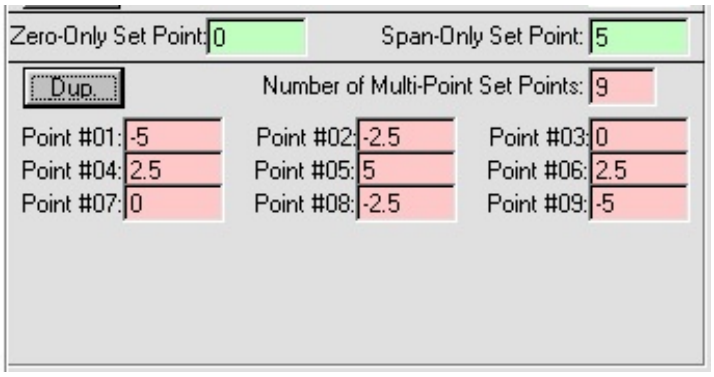
The **[Help]** button is used to assist you in choosing five (5) **Multi-Point** set points, and the **Zero-Only** and **Span-Only** set points automatically, per PSI factory standards — based on either the LRN's assigned calibrator range — or based on the Range of a specified scanner channel — or based on a particular Range Code (a particular internal transducer's factory-specified range identifier). After clicking the **[Help]** button another auxiliary frame (with a *white* background) pops-up to the left of the button, obscuring the **Calibrator's Range** column of controls (see example above).



Showing [**Help**]'s **Pick Set Points** frame overlaying Range column

This *white* pop-up frame stays on the form until you dismiss it (by pressing **[Done]** on the pop-up itself, or by pressing the **[Help]** button again). First, to pick new set points, simply choose the proper criterion from the *radio-button* options at the top of the frame. Then, click the arrow on the middle *list box* to reveal all the choices of your selected criterion. Next, click the one you want. The result is a "final" low-to-high range string that appears in the bottom *text box*. If that is the range you want to choose new set points with, then click the **[Pick]** button. Otherwise, you may actually click the text box to edit the two numerical end points appropriately, and then press **[Pick]**. The new set of points then appear in the Multi-Points frame at the right (like those shown *dark pink* in above example). If you don't like these points, pick another criterion and try again.

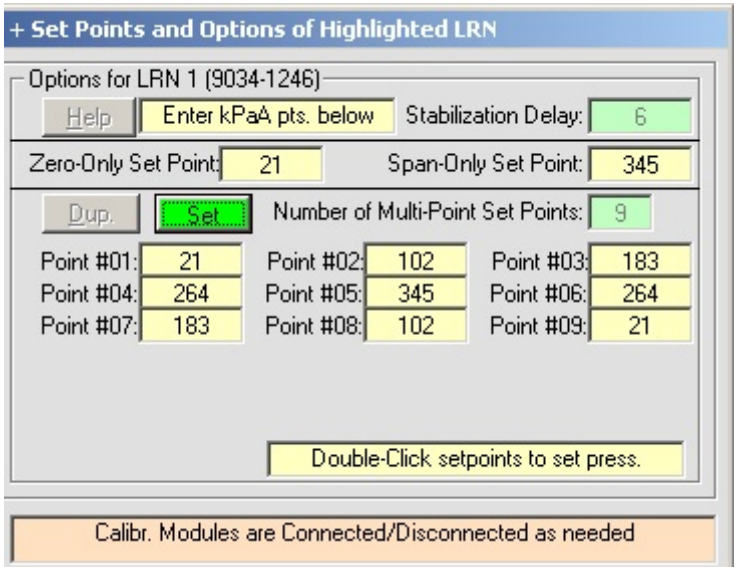
You may want to duplicate some calibration set points more than once if you want to account for hysteresis (backlash) effects. However, a special button labeled **[Dup]** does that for you automatically. If you have already entered a list of *unique* calibration set points: increasing in value from lowest to highest, and then press **[Dup],** it adds additional points to the Multi-Point frame that duplicate these same points — decreasing in value from the highest (which is not duplicated) back to the lowest again. Pressing **[Dup]** again deletes these extra "hysteresis" set points. Try it.



showing results of [**Dup**] button

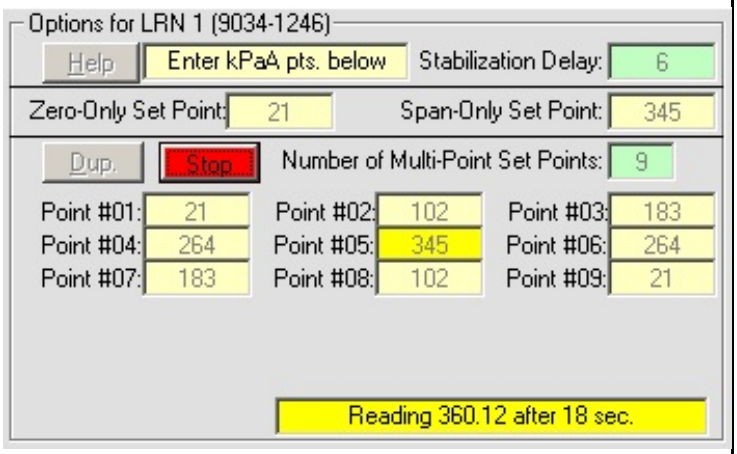
The only other time that default calibration set points are ever assigned is when you initially assign a *new calibrator* to an LRN. At that time, factory default calibration points are set according to the *full scale range* of the *calibrator* itself. In that case, the default for the **Number of Multi-point Cal. Points** field is three (3) points (plus default values of Zero-Only and Span-Only set points as well). Again, you can override such defaults by simply entering both their number (and values) manually – or use the **[Help]** and **[Dup]** buttons to specify them automatically.

In the frame containing all the selected LRN's set points, clicking the **[Set]** button (normally gray) enables a **useful diagnostic feature:** the ability to *actually test the particular calibrator associated with these set points.* The **[Set]** button turns *green* when this features is enabled, and the *background color* of all the set points change to its "pressure mode" color. (*light-blue* for differential points, *light-yellow* for absolute points). A prompt message box (in the same color) appears in the bottom right of the frame to indicate what to do next in this mode: which is to simply **double-click** any set-point's text box containing the pressure value you want the LRN's calibrator to **set**. Once this diagnostic mode is enabled, the rest of this form is disabled (except the **[Cancel]** button) until you finish using this feature to set one or more pressures. To return the form to its full normal usage, click the *green* **[Set]** button again, to return it to its normal gray color. If you forget, most of the disabled form's ToolTips remind you.



Selected LRN's Set Points Frame with **[Set]** enabled

Normally, setting pressures in this diagnostic mode, ties up the form, and all of NUSS, while it waits for the calibrator to set each point. The prompt field (bottom right of frame) indicates the progress of each pressure setting operation (current pressure reading and time). The double-clicked set point value turns *bright-yellow* to indicate that its pressure is currently being set (see example above). It turns *bright-green* when the calibrator declares it set, or turns *bright-red* (and stops the setting) if it takes longer than 120 seconds. In the meantime, the **[Set]** button has also changed into a *bright-red* **[Stop]** button – to allow you to manually stop the setting option.



Diagnostic mode showing pressure being set

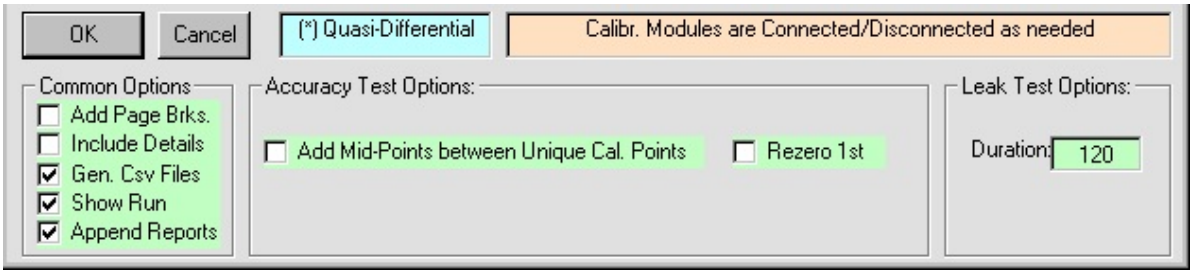
If you do so the set point becomes *bright-red*, and the *green* **[Set]** button is restored – so you can now set other pressures on other set points.

To change the calibrator, you must first click the green **[Set]** button to make it gray again, and to disable the diagnostic mode. Then, you can click any other LRN assigned to a pressure calibrator, on the left side of the form. Then, click the gray **[Set]** button again to re-enable the diagnostic mode for setting any of the new set of set points specified for the new calibrator (LRN).

Although we have been picking *pressure calibration* set points on this form, specifically for the ***Calibration Adjustment*** form described later in this chapter, you do discover later that these set points are also useful to several other NUSS forms. In particular, the ***Pressure Accuracy Test*** form for scanner modules uses these *calibration* set points — but adds extra *test* points halfway between each of them (if an option described below is set for that test).

The *light orange* status box in the middle of form normally contains a note indicating that modules may be briefly connected, as needed, by the form. Modules are connected only briefly when an LRN-to-calibrator assignment is changed, so that it can read the range of the newly assigned calibrator (which is then displayed in **Calibrator's Range** column of controls on the form). Also, if you use the **[Help]** button to pick new set points – based on the range or any *calibrator* or *scanner* module – then that module is also automatically connected briefly (to get and display its range on the Help form). This status box may also be used occasionally to display error messages or other status conditions. Finally, if you enable the diagnostic mode by clicking the gray **[Set]** button (to make it green), the calibrator is connected (if needed) when you double-click a set point to set its pressure. The calibrator is again disconnected when the setting is complete or stopped. None of these automatic connect or disconnect operations, described above, need be performed if you enter this form initially with the subject calibrator(s) already connected.

At the bottom of the ***Configure Calibrators*** form (see example below) are three frames of controls that have no obvious connection with LRNs and their associated calibrators and set points. They do, however, specify special options for running each section of the ***Calibration Adjustment*** function, and also for several explicit ***Test*** functions that use LRN assignments or otherwise generate reports. These options frames generally supply "default" options to these other ***Test*** and ***Calibration*** programs, so as to make it unnecessary for you to specify so many options on the other program's forms – when they are eventually executed.



Bottom of ***'Configure | Calibrators'*** form, showing various Options for Test/Cal programs

The first (leftmost) frame is titled **Common Options**. Most of these five *check-box* options determine the optional content of the *report file* generated when the ***Calibration Adjustment*** function is eventually executed. These options are also applicable to the *report files* generated by other ***Test*** functions (see ***'Test | Leak Check'*** or ***'Test | Pressure Accuracy'*** menu selections) as well — thus the title **Common Options**. Such reports *always* begins with a series of text header lines (indicating which modules are being adjusted, or tested, and how). These also indicate which LRN (one or more) is being adjusted/tested in that report's session. Within the following sequential LRN report section(s), any **error messages** that occur during the ***adjustment*** (or ***test)*** program are *always* included, as are any **Summary Data** in the form of tables.

If the first *check box* labeled **Add Page Brks.** is checked then the various tables and report sections are separated from each other by *page breaks* as the report file is generated. Without page breaks being specified, each report file is a continuous scroll (that saves paper when printed). See also note below about page breaks.

If the second *check box* labeled **Include Details** is checked then a detailed sequential listing of every internal event executed during the adjustment or test is included in each report. Some of the data from the summary may also be duplicated in this part, but in a different "sequential" form. Although adding this information makes a report overly verbose, it may be useful to you if error messages (and summary data) alone are not sufficient to indicate what went wrong — when a particular ***adjustment*** or ***test*** session fails for some reason. You would NOT check this option for normal operation.

If the third *check box* labeled: "**Gen. Csv Files**" is checked then a special *comma-separated-variable* (**.csv**) file is generated – in addition to the directly readable text (**.txt**) file of each report. These additional generated files are more suitable for loading into a spreadsheet application but are not as directly readable.

NOTE: If the ***Add Page Brks.*** Report Option (described above) is selected, such page breaks are generated as *Form-Feed* codes (ASCII 0xC) embedded in the report's text file at the point where each page break is needed. Unfortunately, most Windows standard text editors (WordPad or NotePad) ignore such codes, simply showing them as a tiny box in the printed or viewed text file. If you really need to print with proper page breaks, then assign a more adept Text Editor to NUSS (with ***'Configure | General Options (NUSS)'***) for report viewing and printing.

A *fourth* check box is labeled ***Show Run***, which is an abbreviation of **"Display a Run form for each affected module"**. This is the only General Option that does not affect the format of a Test/Cal report file. When checked, it causes that start of each Test/Cal program's session to pop-up instances of the *minimum* ***Run*** form for each scanner module these programs are currently affecting. See **Section 4.8** for more information on this feature. Such auxiliary ***Run*** forms allow you to see the effects of setting calibration set-points (and making the final calibration adjustment) on each module's displayed data.

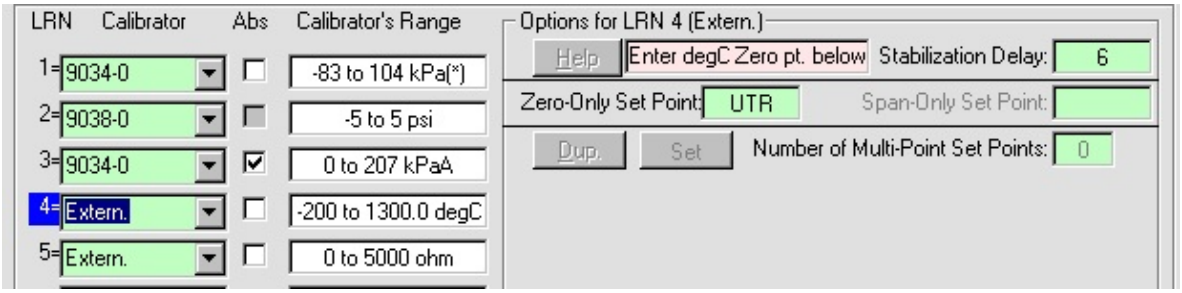
A fifth check box is labeled **Append Reports**. Each Test/Cal program has a similar check box (abbreviated **AppRep**) that appears on that program's form, which simply has this check box's option setting copied to it, by default, at the time the program is started. Thus, for each Test/Cal session you perform, after its program is loaded, you may choose to append that session's report to the existing report file or not. This option affects both the main text report files and the optional **.csv** report files.

The other *two frames* of controls at the *bottom* of the form belong to specific ***Test*** functions exclusively. They specify other "default" options that are already set (on the forms of those programs when they run). See the sections on **Pressure Accuracy Test** and **Leak Test** in **Chapter 5** for additional details.

4.1.1.4 LRNs For Calibrating Temperature/Resistance Scanners

A subset of the LRN association scheme described above for *pressure* scanners can also be used for calibration of the Model 9x46 *temperature* and *resistance* scanners. Those scanners have only a *Zero-Only* adjustment function however, and can NOT participate in any *Span-only* or *Multi-Point* calibration. This *Zero-Only* (offset coefficient adjust) calibration of an 9x46 module is accomplished first by assigning the affected channels to one or more LRN(s), that represent the particular *temperature* (or *resistance*) range to be adjusted. In effect, you are defining a particular *temperature* (in degC or degF) or *resistance* value (in ohms) that you want adjusted when the Zero-Only calibration function of the 9x46 is later executed. Next, we must assign an appropriate calibrator to this same LRN with which the affected channels are associated.

See example below, and note particularly the rows for LRN #4 (highlighted) and #5.



Since there are no "real" temperature/resistance calibrators known to NUSS, an imaginary external (**Extern.**) Calibrator must be assigned to the LRN(s) of interest. The range of this LRN is then manually edited – to be some suitable *temperature* or *resistance* range (in degC or degF or ohm(s)) – depending on the particular 9x46 affected channels that are associated with this calibrator. For example, any of the following 4-token text strings may be edited in the **Calibrator's Range** text box for that LRN:

<low> to <high> degF or
<low> to <high> degC or
<low> to <high> ohm(s)

Since no degree (°) character generally exists on a computer's editing terminal, the units must be entered as shown in text string examples above. Also the particular units (degC or degF or ohm(s)) must match the units the particular 9x46 modules has been configured to generate for all of its temperature channels (see ***'Configure | Transducer Options'*** for 9x46). The <low> and <high> range end-point values are arbitrary and not really used – but must be entered to satisfy NUSS that four space separated tokens are included in the range string. The 4th *units name* token shows up in the adjustment report, however, and

should be specified correctly as you want it to appear in the adjustment session report. The first 3 characters of the *units* name also determines additional rules about how the calibration data are processed, and how the user is prompted when the Zero-Only calibration adjustment is started.

Next, a particular *temperature* or *resistance* value – or (in the case of thermocouples TC channel adjustments only) a special name "UTR" – must be entered into the **Zero-Only Set Point:** text box. Notice that most of the other data values in that frame need NOT be specified and are actually disabled, since no other type of calibration adjustment can be performed for the Model 9x46. Likewise, the **[Help]**, **[Dup]**, and **[Set]** buttons have no useful purpose for these modules, and are disabled

The other side of the LRN equation requires that you also specify, for each 9x46 transducer channel, the appropriate LRN that specifies its adjustment set point. Also, you should specify that this LRN uses for the valve settings of *None* – since the module has no pneumatic valves.

After both sides of the LRN equation are satisfied, the ***'Calibrate | Zero-Only'*** function can be executed for the single-module or group of modules containing it. **However, we do not recommend that such modules calibrated in groups that include *pressure* scanners – since the operator prompting messages for temperature and pressure scanners are so different.**

After reading the general information in **Section 4.5** (geared for *pressure* scanners) proceed to **Section 4.5.1** for details on actually performing a Zero-Only calibration adjustment session for *temperature* and/or *resistance* scanners.

4.2 Zero-Only Calibration Adjustment

Proceed to **Section 4.5** for details on actually *performing* a *Zero-Only* calibration adjustment session for all scanners. For *temperature/resistance* scanners, see the previous section (**4.1.1.4**) first. Continue reading for more information on setting up all types of *pressure* calibration adjustments.

The *Zero-Only Calibration Adjustment* function adjusts the *Offset* adjustable coefficients only of its subject transducers. It operates procedurally like the other adjustment functions, but only stimulates the subject pressure scanner module(s) with a single "zero" pressure value (i.e., a physical pressure value (zero or otherwise) that you want to "read" *zero* after the calibration "offset" coefficient adjustment has been made). The function adjusts each selected LRN, sequentially. This particular pressure stimulation can often be obtained by simply opening the chosen scanner's individual *Run* valves (or the manifold *Cal* valve) to atmosphere. However, NUSS normally requires a real *calibrator* module be connected – via the specified valves, and *sets* the specified physical pressure when automatic operation is desired. However, you may specify the **None** valve position to avoid this requirement – which causes NUSS to prompt the operator to set any necessary external valves (as might be necessary for a 9022 module with external transducers and no internal valves).

4.2.1 Zero-Only Calibration Valve Control

Most 9x16 scanner modules expect to use the *Cal* valve to apply the zero pressure, and selects that valve automatically when the built in Zero-Only calibration command is executed. However, NUSS defeats this option, and uses whatever valve was specified for the transducer(s) by its *LRN-to-transducer* association function described in **Section 4.1.1.2**. There is even a low level module command for determining whether a module sets this valve automatically or not. It does not matter how this option is set in the module when you use NUSS, since it disables any automatic valve setting – and only uses whatever valve is configured to start calibration with, for a particular LRN.

4.3 Span-Only Calibration Adjustment

The *Span-Only Calibration Adjustment* function adjusts the *Gain* adjustable coefficients only of its subject transducers. It operates procedurally like the other such pressure calibration adjustment functions, but only stimulates the subject scanner module(s) with a single "upscale" pressure value, for each selected LRN. This Span-Only set point is generally set *near* the full-scale limit of the each transducer affected. This can only be obtained by having a real *calibrator* module set the pressure. Not only does the *Span-Only* adjustment function use this Span-Only set point – but the ***Leak Test*** for scanners also uses it.

Proceed to **Section 4.5** for details on actually performing a Span-Only calibration adjustment session for *pressure* scanners.

4.3.1 Span-Only Calibration Valve Control

Most 9x16 scanner modules expects the *Cal* valve to be used to apply the span pressure. NUSS uses whatever valve was specified for the transducer(s) by its *LRN-to-transducer* association function described in **Section 4.1.1.2**.

4.4 Multi-Point Calibration Adjustment

The *Multi-Point Calibration Adjustment* function adjusts both the *Offset* and *Gain* adjustable coefficients of its subject transducers at the same time. It operates procedurally like the other such adjustment functions, but stimulates the subject scanner module(s) with two or more pressure points (some set points may be repeated). These set points generally cover the entire useful range of each transducer affected, or at least a sub-range representative of a particular usage. This can only be obtained having a real *calibrator* module set each of these pressures. If your set points include any *differential* pressures below or near zero (or any *absolute* pressures below "atmosphere") a vacuum pump must be installed and running.

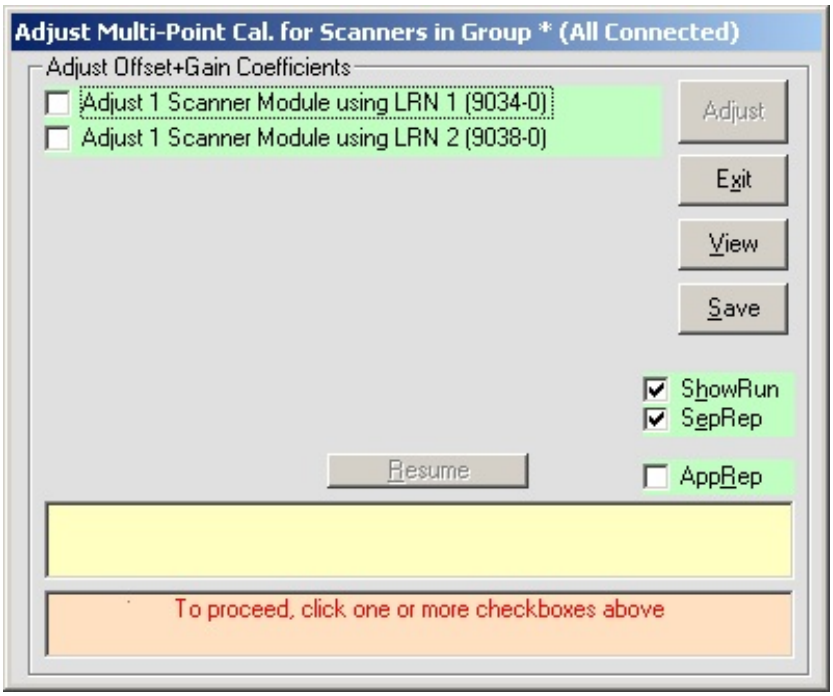
Proceed to **Section 4.5** for details on actually performing a Multi-Point calibration adjustment session for *pressure* scanners.

4.4.1 Multi-Point Calibration Valve Control

Most 9x16 scanner modules expects the *Cal* valve to be used to apply each of the specified multi-point pressure values. NUSS uses whatever valve was specified for the transducer(s) by its *LRN-to-transducer* association function described in **Section 4.1.1.2**.

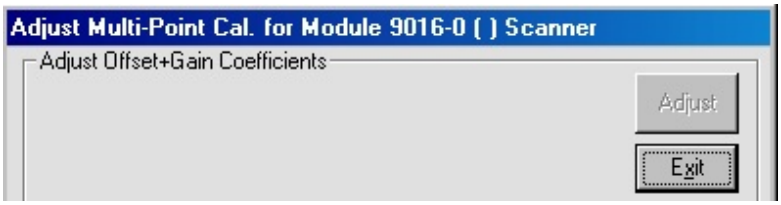
4.5 Performing The Adjustment

After a particular ***Calibrate Adjustment*** function is selected from the *context* menu for a *single module*, or is selected from the *home-base* menu for a *group of modules*, the following form appears (e.g., a **Multi-Point** *adjustment* of Group *Star's (*)* modules).



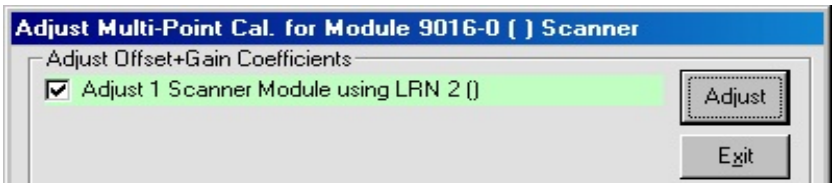
Initial ***Calibration Adjust*** form

The main frame of this form (whose title indicates which calibration coefficients are adjusted), shows from 1 to 8 selectable *check boxes*. These *check-boxes* represent each pre-assigned LRN, that may be adjusted (for the group or single module), and that has been pre-specified by the *calibration adjustment configuration* tasks described in detail in **Section 4.1**. In the example above, two check boxes are shown for two pre-specified LRNs (1 and 2 in this case). If there are NO check boxes shown, then you have failed to do one of two things. Either you have not defined any LRNs or you have not associated any scanner module channels with any LRN. In both of these cases you are asked to immediately Exit the form, and the **[Exit]** button has the current keyboard focus.



The bottom two status boxes indicate these two conditions as follows.

Before you can start an ***adjustment*** *session* first check one (or more) of the displayed LRN choices. The **[Adjust]** button remains dim until at least one LRN is checked. If only one LRN is pre-defined for this module or group, it is already pre-checked as in the example below.



When there are multiple LRN check boxes shown, this selection procedure determines which, of all the possible LRNs, you plan to adjust in a particular adjustment session. The remaining buttons are initially *enabled* to allow you to:

(1) **[Exit]** the adjustment form (if you entered it by mistake);
(2) **[View]** (or print or copy or move or rename or delete) the *last* report generated by a *previous* session;
(3) **[Save]** the *previously* adjusted coefficients in non-volatile transducer memory.

Several check boxes also appear on the form before a session begins.

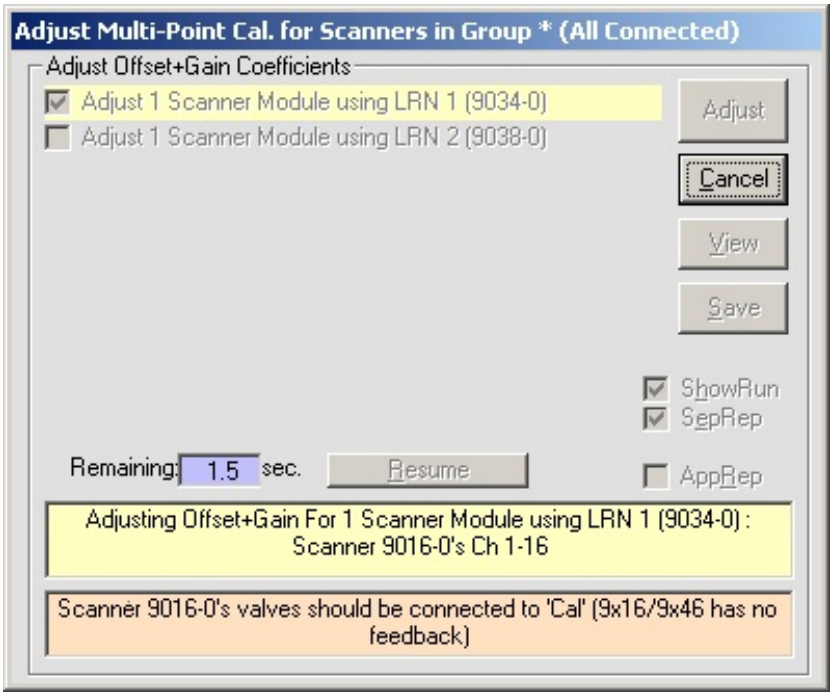
(1) The ***ShowRun*** check box (short for *Show* ***Run*** *Forms*) may be checked or unchecked by default since its state is inherited from the Common Options frame on the ***'Configure | Calibrators'*** form. When checked it causes minimal ***Run*** forms to pop-up (to the right of the *adjustment* form) for each module actually being adjusted – after the session begins for each selected LRN.

(2) The ***SepRep*** check box (short for *Separate Reports*) only appears when multiple modules are specified in the LRNs of a module Group. This check box is normally checked by default. When checked it causes a *separate report* to be generated for each module – as well as the main report which

includes information on all the modules adjusted in the group. This checkbox does not appear if a single module is adjusted.

(3) The **AppRep** check box (short for *Append Reports*) may be checked or unchecked by default since its state is inherited from the Common Options frame on the ***'Configure | Calibrators'*** form. When checked it causes the reports of multiple sessions to be appended across these sessions – instead of the newer reports overwriting earlier reports. When unchecked, you need to save any reports (or give them unique names) at the end of each session if you do not want them overwritten

After the **[Adjust]** button is clicked to start the session, the form changes (see example below). All *check box* choices and all buttons, except **[Cancel]** (formerly labeled **[Exit]**), are now disabled and dimmed. Clicking **[Cancel]** aborts a session already started by mistake



The Calibration Adjust form after Adjustment Session Started

During the entire adjustment *session*, all the transducer(s) of module(s) associated with the each checked LRN is performed, sequentially, one by one. The LRN currently being adjusted is highlighted light yellow. All the LRN check boxes are also dimmed. In the example above only one module associated with one LRN is being adjusted, even though two LRNs were defined. Also, because the **Show Run** *check-box* was checked, the *minimum* ***Run*** form (of each module assigned to the current LRN) appears automatically to

the right of the *adjustment* form until adjustment is done for that LRN. When more than one module is being adjusted, several ***Run*** forms are cascaded, but you my click the desired form's title bar to bring it to the foreground for viewing. An example of these cascaded ***Run*** forms is shown in Section 4.8 at the end of this chapter.

During each adjustment *procedure* (i.e., for the highlighted LRN check box), two status boxes near the bottom of the form keep you informed. The top status box (light yellow) indicates *which* LRN is currently in progress, while the bottom status box (light orange) either prompts you to set pressures or close valves manually — or it indicates the progress of the same actions being done automatically behind the scenes. Any programmed delays (longer than one second) are displayed in a third "count-down" *blue* status field that only appears when activated. It is there to help you manage your impatience during each necessary delay. The *reason* for the delay may also be indicated by the bottom status box.

EXTRA ZERO DIFFERENTIAL SETPOINTS:

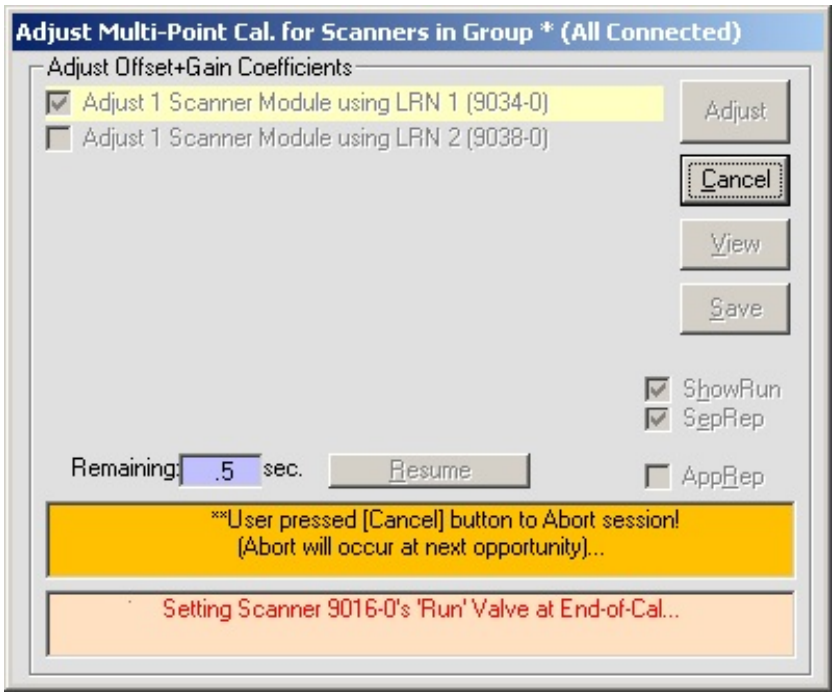
For high-pressure Absolute Quartz calibrators (with range > 100 psia or equivalent other native units) that are operated in the quasi-differential mode, extra zero (0.0) set points are set by the Multi-Point Calibration procedure – preceding the setting of any non-zero differential set points specified for the subject LRN. These extra zero settings show up in messages in the status box at the end of the form. They are used only to improve the setting accuracy of the specified set points. The final status report has only a single header message indicating the use of these extra zero points, but no data are collected for them.

Manual action prompts occur only if you have pre-specified an **External** calibrator (e.g., laboratory dead-weight tester or a special *temperature* or *resistance* calibrator) instead of one that can be automatically *controlled* by NUSS software). These prompts replace the normally automatic actions of the adjustment procedure, and generally expect the user to close any external valves appropriately – and to create any necessary delays. For modules that have no pneumatic valves anyway (e.g., 9022, 9x46) you can specify "imaginary" valves to be used anyway – which suppresses all the prompts you get when **None** is specified. Normally, however, Model 9x46 temperature/resistance scanners should specify **None** always so that their special operator prompts (particularly for the special Auto-UTR type Zero-Only adjustment of TC channels) are seen by the operator.

Status messages in the bottom status box may blink (red-black-red-...) to draw your attention to them, particularly if some manual *prompted* action is required of you. In that case, a **[Resume]** button, located in the middle of the form just above the status boxes, is enabled. It allows you to *resume* the adjustment procedure when you have accomplished

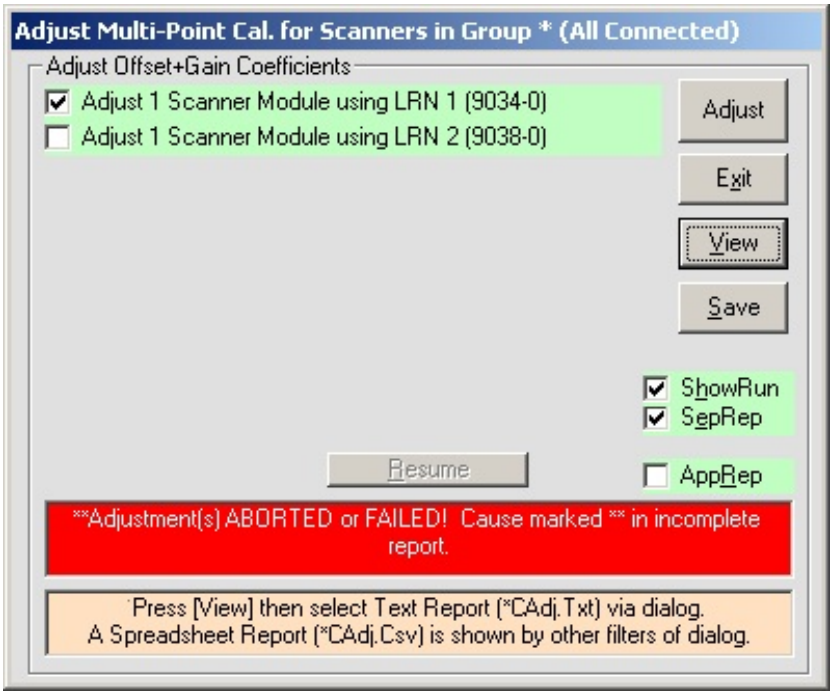
the requested manual action (and accounted for any necessary manual delays). Some error messages not only blink but sound a *bell* signal to alert you (if your PC has a sound card with speakers and the volume is turned up).

Any unbounded hangups (e.g., as while waiting for a calibrator to set a pressure that it can never set, because you forgot to turn on a vacuum pump) may be cleared, and the remainder of the adjustment procedure terminated, if you press the **[Abort]** button. This button may appear in place of the **[Resume]** button during some abort-able steps of the procedure. You may also press the **[Cancel]** button, at any time during the adjustment session, to forcefully abort the *remainder* of the *current procedure* and *overall session* at the next suitable breakpoint. At most, you would only have to wait for a few seconds, after clicking this button, before ending the session. If the adjustment procedure detects any serious errors it may also self-abort the session. In either case a "transitional" version of the form appears as follows (or similar to it):



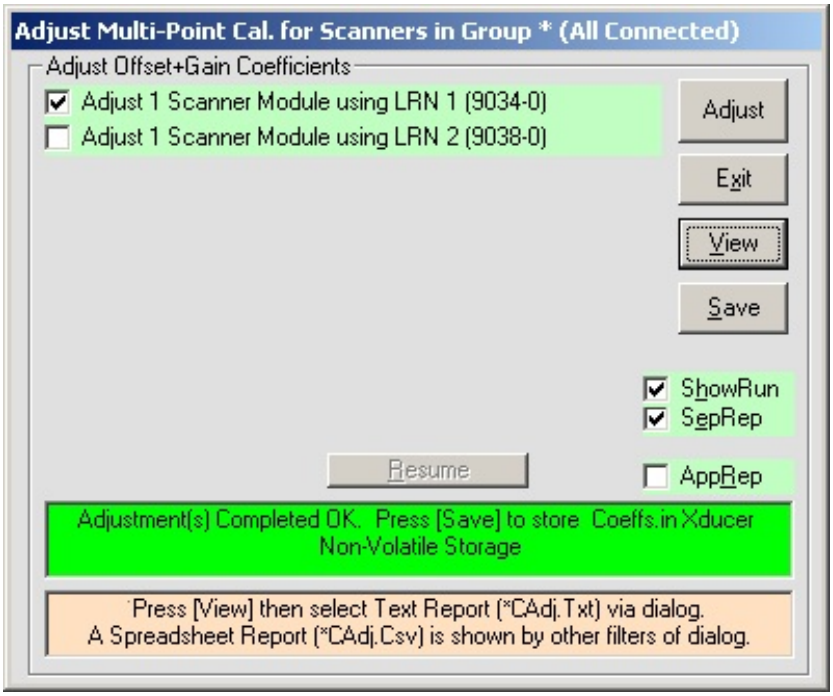
For self abort errors, the bottom status box of the "transitional" form may contain a description of the actual error detected (that also appears in the final incomplete report). The bright orange upper status box may contain a message demanding that you press the **[Resume]** button to acknowledge the displayed error.

Eventually, the final form appears as follows.



All buttons are now enabled again. Click **[Adjust]** to start a new session, possibly changing the LRN check boxes before you do so. However, if the session self-aborted, it is likely you do experience the same error again and abort again. Click **[Exit]** to leave the form, but normally you would click **[View]** first, to examine the incomplete report. Some error message preceded by two stars (**) are found somewhere in the report to indicate the reason for any aborted session. The **[Save]** button is normally disabled if the session just ended failed in any way. However, it may still be enabled to allow adjusted coefficients (Offset and/or Gain) from a previous successful session to be saved.

If an adjustment session is completed it may appear in one of two possible ways: with a *bright green* or *bright yellow* upper status box. If there were no errors detected and all adjustments to coefficients were within tolerance, the form on the following form would appear:



If the adjustment session ended without any errors but some adjustments made to its coefficients were out of tolerance, the bright green message above might be replaced by a bright yellow one instead. The message would request the user view the final report for specific out-of-tolerance data values marked with stars (****). Read more about these special color indicators below.

All the calibration *set points* to be set during a particular LRN adjustment *procedure* are predefined uniquely for each LRN, thus facilitating automatic operation as much as possible. Also, the particular real valves in the scanner modules that must be set to start calibration (Cal/Run/None) and the valve to set when finished, must all be pre-specified by the single-module ***'Calibrate | Associate LRN***(s)' menu item. See **Section 4.1** for these setup functions.

The calibration data are collected, displayed, and saved during each LRN adjustment *procedure*. After every pre-specified calibration point has been applied, new **Offset** or **Gain** or *both* coefficients (as indicated in main frame title) are calculated, as necessary. When such a procedure is completed for a particular checked LRN, the procedure may then repeat — for any other *checked* LRNs with *check boxes* visible on the form. In other words, when more than one LRN is checked during a session, each LRN is adjusted separately and sequentially (not concurrently).

When a *session* ends (i.e., all checked LRNs have been adjusted), the **[View]** button is enabled to allow you to examine the report generated during the session. The results of all LRNs adjusted appears sequentially in the final session report. Viewing session report data is described fully in the next section below. However, at this point, there are certain visual clues displayed on the form to indicate the results of the adjustment session.

Whether an adjustment session ends normally, or it fails due to some unrecoverable error, it detects, or it is aborted forcefully by the operator, the *top status box* (with a *light yellow* background color during the session) changes to an appropriate *final bright background color* that indicates the quality of the data in the session Report file waiting to be viewed. This *bright background color* can be seen, from across the room, once the session has ended. It provides a simple *success*, or *caution*, or *failure* indication in visible form, as follows:

- If the session is *aborted* by the operator or *terminates* itself due to a detected error, this status box's background color may initially change to *bright orange* — during the time it takes for all operations to cease. However, the color eventually changes to *bright red* to indicate that the session failed and an *incomplete* report file now awaits viewing.

- If the session and its report file are *complete*, but one or more *out-of-tolerance data items (or ignored errors)* are flagged somewhere in the report (i.e., marked with two or more *asterisks*), the background color is *bright yellow* to indicate that the report must be scanned to find the flagged items. The color is *bright green* if the adjustment was completely *successful* (i.e., *no datum is flagged and no ignored error has occurred* anywhere in the complete report) .

After a *session* is done, the form returns to its original state, with check-boxes enabled, except that the **[Adjust]** button (and all other buttons) is enabled. This allows you to check or uncheck any other LRN check-boxes to run other sessions, or just to examine the results report of the previous session (as described next). If you start a new session immediately, the report for the just ended session is *overwritten* unless you check the **AppRep** checkbox (which forces the next session report to append to the end of any older copies). This checkbox is always unchecked by default.

The test results report should be the same for *pressure* scanners and for *temperature* scanners – except for the *units* of the real or imaginary set points used (more about the report in next section).

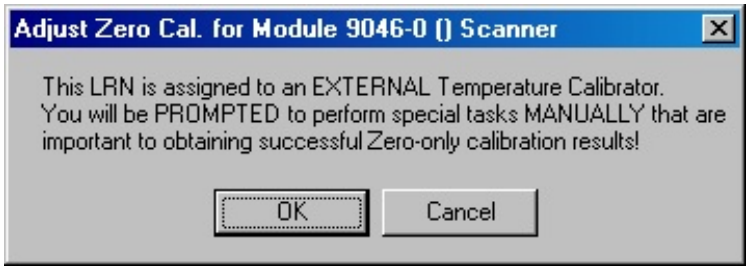
Since each LRN is adjusted sequentially, you may mix *pressure* and *temperature* LRNs in one session for a module group. Likewise, you can adjust single modules with multiple LRN's (e.g., for dissimilar transducer ranges in that module) in the same session.

A module group with one or more *temperature* scanners should only execute a *Zero-Only* adjustment, however. If you try to perform a *Span-Only* or *Multi-Point* adjustment on a *temperature* scanner, the results are unpredictable and unsatisfactory.

4.5.1 Zero-Only Adjustment for Model 9x46 Modules

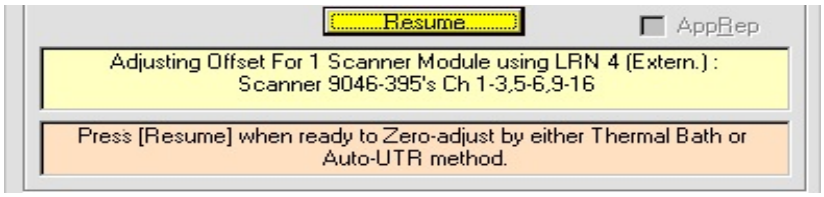
When a Model 9x46 temperature/resistance scanner is calibrated, only the Zero-Only form of adjustment is allowed. During setup of LRNs for calibrating the various temperature channels or resistance channels, it is practical to separate such mixed channel (sensor) types so that each is calibrated with its own unique LRN. For example, the special **Auto-UTR** method applies only to thermocouple (TC) channels. Since this method prompts the operator to remove all actual thermocouples and short their inputs, a unique LRN is almost a must. This is also a reason such LRN's are not calibrated with other pressure scanners where most of the calibration operations are automatic – and do not require any prompting of the operator. The following description illustrates both this **Auto-UTR** method of adjustment as well as the **Thermal Bath** method where a particular temperature is specified for the Zero set point value. A *resistance* calibration adjust is similar to the **Thermal Bath** method for adjusting thermal channels because a numerical set point value is given..

When we execute the ***'Calibrate | Zero'*** function and any selected LRN has an **Extern.** calibrator assigned with **degC** or **degF** units specified in its range, the following notice box appears first:



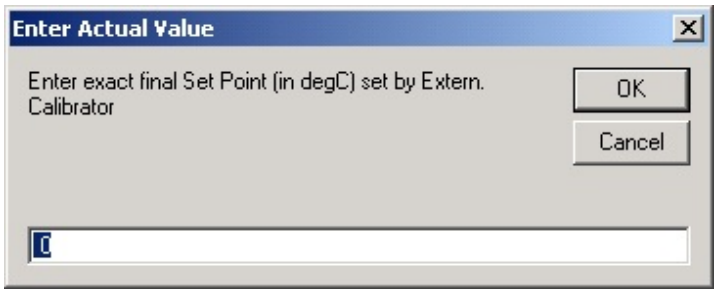
Press **[OK]** to acknowledge the fact that you are prompted to manually control our "imaginary" temperature calibrator, instead of the program automatically setting it (as it would for a real Pressure calibrator). A resistance calibrator would pop-up a similar message, but the word *Resistance* replacing the word *Temperature*.

Next, you get a prompt (see message blinking between red and black text in the light-orange status box at the bottom of the form). This indicates that one of the Zero-only thermal methods for 9x46 channels is about to start.

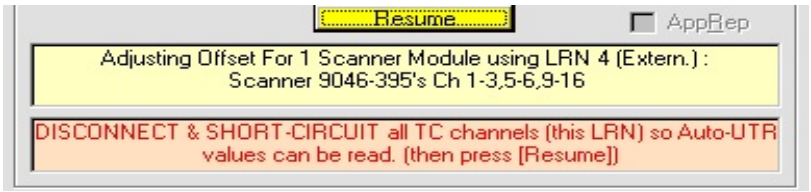


Simply clear this prompt by clicking the **[Resume]** button.

If the *Thermal Bath* method of Zero calibration is to be performed for any mixture of TC and/or RTD channels of the 9x46 module, the following pop-up dialog requests you to enter the "actual" *Set Point* that was set by the "imaginary" calibrator. An almost identical pop-up appears for a *resistance* calibration, but with units changed to *ohm(s)*. Click in the value box to enter this "exact" *Temperature* or *Resistance* value (if the default value shown is not exact). Click **[OK]** to continue. Clicking the **[Cancel]** button shuts down the Zero calibration adjustment immediately.



If the *Auto-UTR* method of Zero calibration is to be performed (for only TC channels of the 9x46 module) you do not see the above **Enter Actual Value** pop-up. Instead you get an additional prompt instructing you to disconnect the thermocouples connected to the affected LRN channels, and then short circuit their input terminals with a jumper.

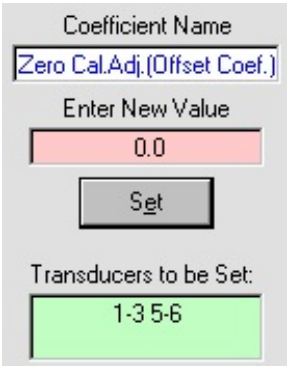


When this manul setup operation is accomplished, clear this prompt by clicking the **[Resume]** button. Internally, each affected channel has its UTR junction temperature read

by a special command, and that value of temperature is used to adjust the Zero (offset) coefficient of that channel.

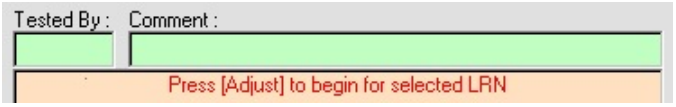
The calibration adjustment, by either of the selected methods, now takes place, and if the ***Run*** form is visible, you may actually see the data change on the adjusted transducers. At this point the new *Offset* coefficients for each adjusted transducer (channel) has only been stored in the volatile (working) memory of the module. These results can be viewed on the **Run** form indirectly, and in detail by examining a *Zero Adjustment Report* that can be viewed by pressing the **[View]** button on the form. If your decide that you do not like the results of the adjustment, you should click the **[Exit]** button – without first clicking the **[Save]** button (which would permanently change the coefficients in the module).

If you click **[Exit]** without saving, you can restore the module to original coefficients by simply executing the '***Reset***' function for the module (second item in top section of module's Context menu). After waiting a few seconds for the module to recover from ***'Reset'*** (when its icon indicates it is available), you can then again '***Connect***' to the module, activate ***Run***, and see that the adjusted coefficients have been replaced by their old copies from flash memory. If you did press **[Save]** the new coefficients replace the old ones in the non-volatile (flash) memory of the module – and the only way to change that – is to go to the '***Calibrate*** | ***View/Edit Coefficients***' form and set the *Offset* coefficient back to its nominal zero value (0.0) for each affected transducer separately. That form also has a feature to allow any single coefficient change to be applied to more than just that channel selected for display.



One unanswered question you might have is: **How do you get rid of bad offset adjustments** after an unsuccessful adjustment session? Simply select **'Calibrate | View/Edit Coefficients'** from the context menu of the affected 9x46 module. Examine each channel's **coefficient 0** (Offset). It can be set to its **nominal (non-adjusted) value zero (0.0)** using the **[Set]** button. By editing other channel numbers into to the text box labeled "**Transducer's to be Set**" before you click **[Set]** you may clear all these channel's **coefficient 0 (Offset)** values at the same time. Click **[Save]** before exiting the form, to make the changes permanent in the module's non-volatile memory. Other module types do not allow normal users to change their adjustment coefficients in this way.

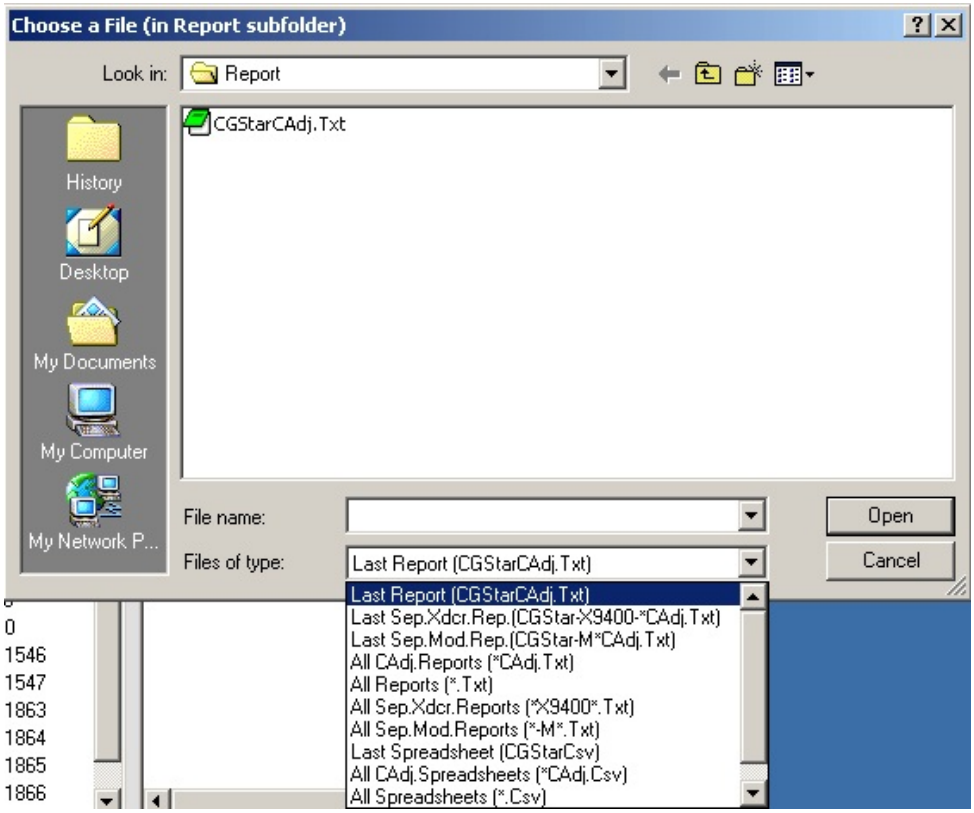
4.5.2 Hidden Controls



Unlike ***Test*** programs (described in Chapter 5) the ***Calibration Adjustment*** programs do not require an operator sign-in before starting. However, an optional operator sign-in (and comment entry) may be invoked when necessary – by *double-clicking* either of the two status boxes at the bottom of the form. Two additional text boxes (and two labels) appear in place of the top status box (see inset above right) Any user ID name string you enter in the box labeled **Tested By:** causes the final calibration report to contain an extra header line that includes this name – and any added comment string you enter in the second box. Double-clicking the form's bottom status box (or either of the two new labels) hides these two extra entry boxes and labels.

4.6 Viewing/Printing/Copying Calibration Reports

When an adjustment *session* is completed (i.e., all checked LRNs are now adjusted) the top status box so indicates as described above, and a **[View]** button is enabled on the form. This allows you to examine the latest Calibration Report text file for the *session*. You may also examine any *partial report* that results — in the event the session self-aborts early (due to errors) or you manually aborted it. The contents of that report contains what was pre-configured by the **LRN-to-Calibrator** *configuration* task (see the **"Common Options:"** frame on example form in **Section 4.1.1.3**).



The Windows **Open** dialog form you get when **[View]** button clicked

Clicking **[View]** pops-up a standard Windows **Open** dialog box, like the one shown on the previous page. In this particular example, all the various file filters have been exposed by clicking the arrow at the right end of the combo box labeled **Files of type:**.

For a *Multi-Point* adjustment the report file is named either ***<modid>CAdj.txt***) or ***CG<groupid>CAdj.txt.*** For a *Span-Only* adjustment it is named ***<modid>CAdjS.txt***) or ***CG<groupid>CAdjS.txt***. For a *Zero-Only* adjustment it is named ***<modid>CAdjZ.txt***) or ***CG<groupid>CAdjZ.txt***. For modules tested in a group, the separate reports generated by

the *SepRep* option are named **CG<*groupid*>CAdj*.txt** in Nuss version 1.2.16 and earlier. Starting with version 1.2.17 these separate report names were simplified to **<*modid*>CAdj*.txt** to make them easier to archive (just like reports generated by testing single modules). All these files are located in the **Report** subfolder *(Main Base Path)*. Click that report name, to highlight it, then press **[Open]** to view it – or simply double-click the report name. An instance of your favorite text editor form pops-up showing the text contents of that report file for you to view.

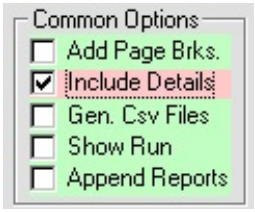
This **Open** dialog form initially begins with a default first (or "Last Report") *filter* set to show only the *most recent single-module* or *coordinated group* reports. In the example above, a Multi-Point *calibration adjustment session* had just been completed for a module group, thus only the most recent such reports are selected by this *first* filter (a Group Star (*) Multi-Point Cal Adjust report named **CGStarCAdj.Txt** in this case). If a *Zero-Only* or *Span-Only* adjustment session had just been completed, then the first filter would show only those session reports in the main display window. Choosing another filter lets you choose from other reports. You can even create your own *custom filter* by typing it into the text box labeled **File name:** (e.g., typing in the string "**9*16*CAdjZ.txt**" would display every Zero-Only calibration adjustment reports for any 9x16 module type).

Anytime a Windows **Open** dialog is displayed, like the **[View]** form above, you may optionally perform other file maintenance functions (print, copy, move, rename, delete, ...) on any of the files shown, using the *context* menu that Windows pops-up when you right-click any highlighted file name. Similarly, file functions like printing may best be accomplished from the menus and buttons of your favorite text editor that is used to display the file.

Behind the scenes, a *parallel* "comma-separated-variable" file, with the same root file name as above, but with a ***.csv*** file extension, may also be written during the session to the same subfolder, if optioned in the **Common Options** box on the home-base menu's ***'Configure | Calibrators (NUSS)'*** form. Although not as human-readable as the similarly named ***.txt*** file, the ***.csv*** file is "ready" to be loaded directly into a spreadsheet application (such as Microsoft Excel). To access it directly from the **[View]** button, you must pick a different *filter* from the Windows dialog box. Suitable filters (for ***.csv*** reports) are shown in the example on the previous page. Click the arrow at the right end of list box labeled **Files of Type:** to reveal the filter list. Click this filter to invoke it, then highlight the ***.csv*** file desired. Next, ***right-click*** your mouse to obtain a Windows *context* menu, and select ***Open*** from that menu (NOT the [Open] button on the dialog box). The file immediately loads into the spreadsheet application that you have *pre-specified (via standard Windows file-extension registration functions)* to activate for all **.csv** files. If you *double-click* the highlighted file name (or choose ***Select*** from the context menu instead of ***Open***), it loads into your favorite text editor instead. When you use the Windows context menu though, you must dismiss the dialog box manually (press **Cancel**) when you are finished with it.

If you immediately start another *calibration adjustment* session, including the same or different LRNs, any *similarly named* old report file results are lost for that *group* or *single-module*, since only a single "latest" report is retained *with that standard name*. This can be prevented if you check the **AppRep** check box described below. Therefore, you must normally view each report when it is completed, and then save it (with the ***'File | Save-As'*** menu function of the text editor form used to view it – or with the ***'File | Archive'*** function on NUSS's home base menu). Normally, you would save it (*move* it or *copy* it) to a Report subfolder in a separate Archive Base Path — elsewhere on your hard disk or some other network drive. You can also *print* it (with the ***'File | Print'*** menu function of the text editor).

Click (check) the normally-unchecked **AppRep** check box (after the first run is completed) if you would like to record several different data runs to the same file. This suppresses the normal overwrite of a similarly-named file if checked. However, leaving it checked can result in some vary large unwieldy files – that eventually require some file maintenance operation. Thus, it is best to get in the habit of appropriately archiving, copying, or renaming the files at the end of each session to avoid overwriting. All report **.txt** files also have one backup copy made (with the **.bak** extension) just before it is overwritten, so you have a 1-time change of recovering from an accidental overwrite.



An example **Calibration Adjustment** Report for a *Multi-Point* adjustment session is listed in Section **F.4** of **Appendix F**. Most of the report examples included in Appendix F do not include any "details". When more information is needed in any report (for diagnostic purposes) then repeat the test – after setting the "Include Details" option – which is specified on the bottom left of the ***'Configure | Calibrators (NUSS)'*** form (see inset). Such reports show step-by-step processing lines, as well as any the user prompts.

4.7 Saving Adjusted Coefficients

After a successful ***Calibration Adjustment*** session, the new *Offset* and/or *Span* coefficients that were *adjusted* for each transducer are only saved in the *volatile* memory inside the module. If the module is subsequently ***Reset*** manually or as a result of a power loss, the improvement in EU conversion accuracy (due to the previous adjustment) is lost. To prevent this, click the **[Save]** button on the *adjustment* form — after the *session* is completed and its report is viewed and verified as correct. It causes all the volatile copies of the new coefficients to be saved to non-volatile memory inside each transducer module that has such a memory. Then, if there is a subsequent ***Reset***, the module's firmware initializes itself by loading these coefficients, from the transducer's non-volatile memory, into the module's working (volatile) memory.

You should take care NOT to press **[Save]** button when the calibration adjustment is unsuccessful — as indicated by a *bright red* or *bright yellow* background in the final test status box at the end if the test. However, if this status box has a *bright green* background, all the new coefficients are correct and within specification. Then you should click **[Save]** to make the coefficients permanent inside the module. This button is dimmed after a successful **[Save]** to remind you that you have clicked it. Also, if you attempt to **[Exit]** without saving good new coefficients, you are warned. You can then **[Save]** them, or **[Exit]** without saving on the second attempt.

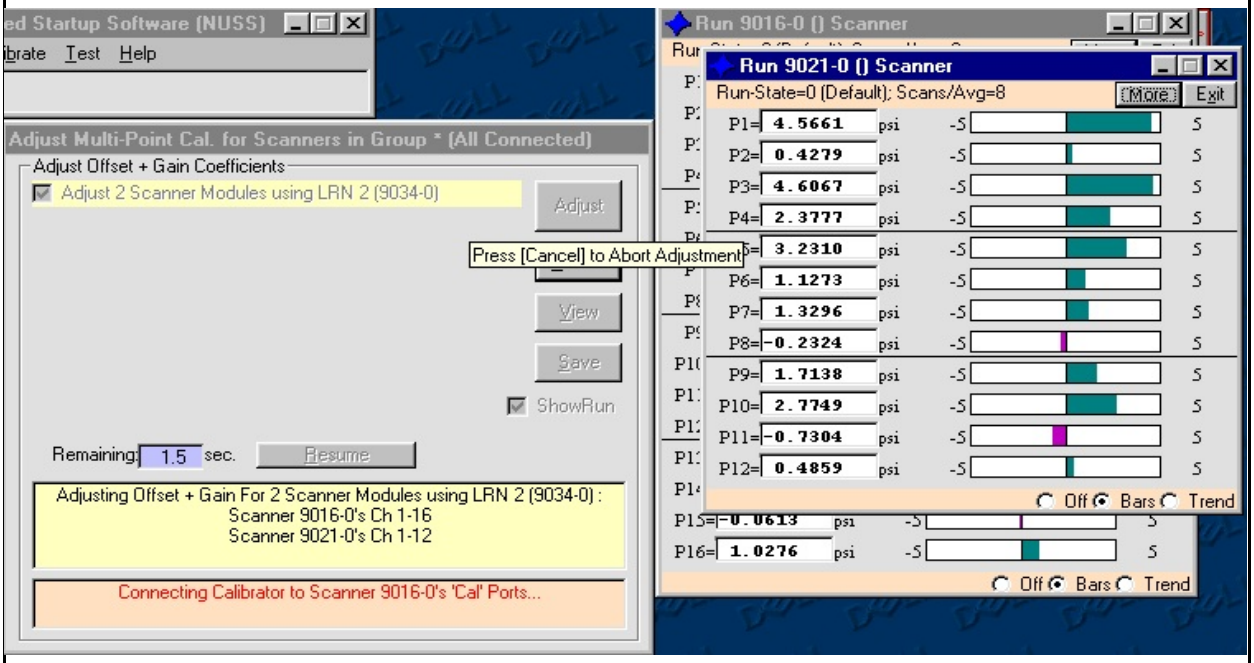
For Model 9022 scanners with external transducers (either Model 9400 types with or without EEPROM non-volatile memory, or generic types without any memory) modern module firmware versions provide some special operations that can save that channel's calibration data in a section of *module* non-volatile memory (flash) instead of in the transducer itself. The **[Save]** button normally handles these special memory copy operations automatically. However, if it fails to do so, there are manual operations in special frames near the bottom of a Model 9022 module's ***'Configure | Other Options'*** form.

4.8 Adjusting With *Run* Form(s) Active

Unlike most NUSS module functions, the ***Calibration Adjustment*** functions (activated for either *group* or *single-module*) are allowed to operate *concurrently* with their affected module's also being operated in ***Run*** forms (either *group* or *single-module*). This provides you with the unique ability to watch the progress of the data improvement (on the ***Run*** form's data displays) as the calibration coefficients are adjusted. Also, for those modules that have valve feedback, you can even watch the valves change. Similarly, the *calibrator* modules may also be active in their ***Run*** forms, allowing you to watch pressure values actually being set. However, you ***must avoid manually changing module functions*** **or changing Run States of the module in these *Run* forms** — while the ***adjustment*** form might *automatically* be doing the same. Also, you should **not** start any ***Run*** form while the adjustment procedure is in progress, since doing so always places a scanner modules *Valves* into the ***Run*** position. Such conflicts of control might lead to bad calibration data. Also, the use of ***Run State 0 (Default)*** is recommended, since certain user-defined run states (e.g., using hardware trigger) might render the module inoperable from the point of view of the ***Calibrate*** *adjustment* program.

In order to avoid worrying about the problems described above — as to"when" to activate "which" form, we recommend you let the ***Calibration Adjustment*** form *automatically* display *simple* ***Run*** forms, when it runs. This is accomplished by selecting the ***Show Run*** *check box* in the **Common Options:** frame of the **LRN-to-Calibrator** configuration form (obtained by selecting ***'Configure | Calibrators (NUSS)'*** from the home-base menu). You can also select this *check box* on the *adjustment* form itself, just before you start its adjustment procedure. However, if you check it on the *configure* form, it is already checked by default on the *adjustment* form. Unlike ***Run*** forms that you activate manually, these *simple* ***Run*** forms pops-up automatically to the immediate right of the *adjustment* form, *cascaded* (on top of each other with slight offsets vertically and horizontally), and be temporarily forced to use **Run State 0**. The normally remembered sizes, positions, and run states of such ***Run*** forms are ignored in this case — but are remembered again when you activate them manually again later. Also, only the particular ***Run*** forms currently being adjusted actually pop up during the running of the ***Calibration Adjustment*** form. They are popped-up, and then dismissed again, just at the proper time for maximum utilization.

Since these automatically popped-up single-module ***Run*** forms are cascaded, you can see the one you want by simply clicking its Title Bar — or clicking its button on the Windows Task Bar. This automatic **Show Run** feature does not pop-up any of the *calibrator* modules being used to set pressures, it pops-up only the scanner modules being adjusted. You may need to have at least an XGA monitor with sufficient resolution in order to use this feature effectively with multiple modules.



Cal. Adjustment form with two ***Run*** forms cascaded to its right (***Show Form*** option)