Nordson
MEASUREMENT & CONTROL

# Series 9

## Colour Measurement Addendum

Publication Reference : 120/17074-01

Issue A

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# Proprietary Notice



**Series 9 Colour Measurement Addendum**

Part Number: 120/17074-01

Issue: A

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## Online Support

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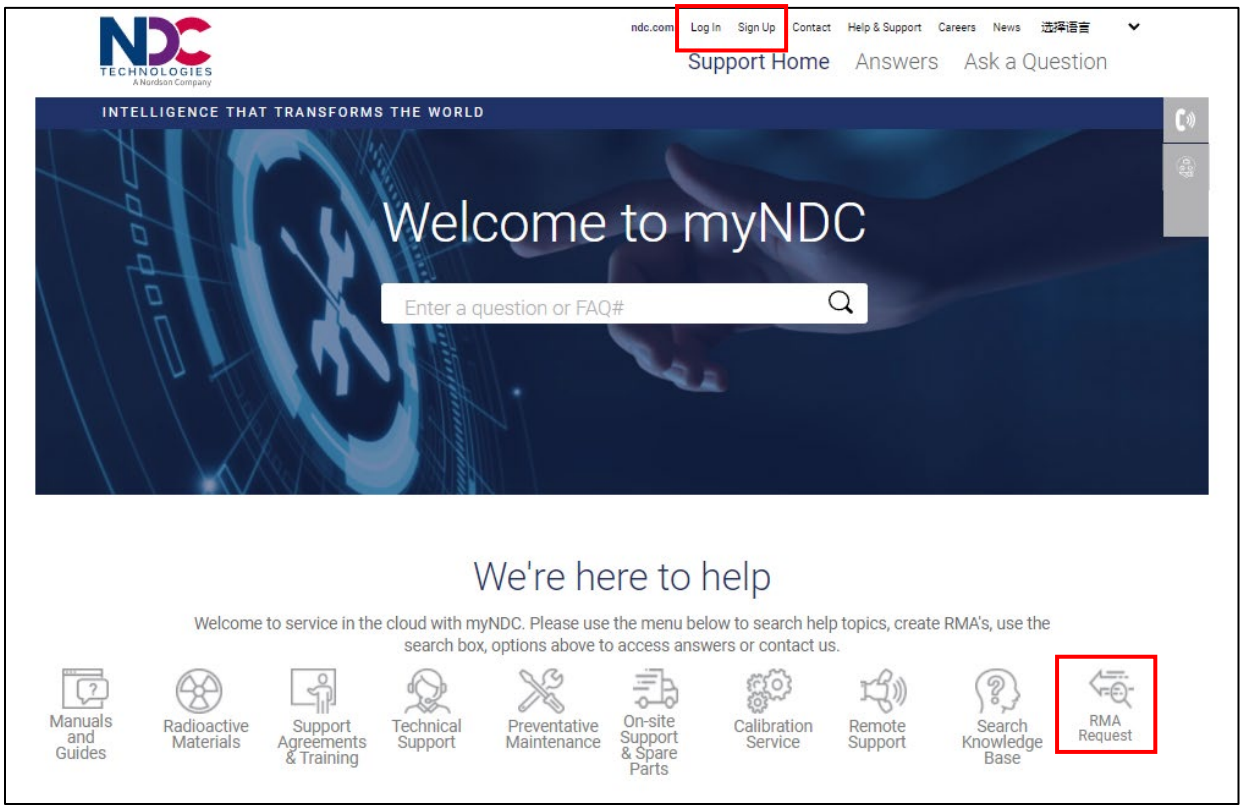
- To create a myNDC account, click **Log In** or **Sign Up**. After creating the account, you will be immediately logged in. To log in on subsequent visits to myNDC, click **Log In**, enter your user name and password, and then click **LOG IN**.

- To submit an RMA, click on **RMA Request** and follow the on-screen instructions.



# NDC Contact Numbers

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CHAPTER 1

# 1 Introduction to Colour Measurement

Colour can be a key indicator of quality in many industrial processes. As such, its measurement can form part of process control in many settings, including the automotive, and food and building materials industries, where consistency of a product's colour is desired. The measurement of colour generally relies on detecting the intensity of red, green, and blue light reflected from an object, as this is how our eyes perceive colour. For example, a lemon reflects a greater proportion of wavelengths belonging to the green and red regions of the visible spectrum light and absorbs more light in the blue region; we therefore perceive the resultant mixture of green and red light as yellow.

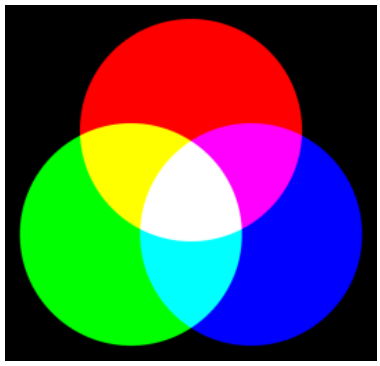

**Figure 1-1 RGB Colour System**

Figure 1-1 illustrates the RGB colour ***system***; however, there are a range of other measurement systems that can be used to represent an object's colour. The most commonly used systems are those defined by the CIE (*Commission Internationale de l'éclairage*), as these mimic the eye's response more closely and are therefore more suitable for application in process control situations. This section of the addendum is designed to provide a brief introduction to colourimetry, colour systems and provide guidance on which colour system is best suited for which application.

## 1.1 Measuring Colour

A number of colour systems have been developed that mimic the human eye's response to reflected light at different visible wavelengths. However, it is desirable to present values to the process operator so that meaningful changes can be made to the process to ensure product consistency and conformance within target specification.

A common method to measure colour is called the tristimulus model, originally developed by the CIE in 1931.

The tristimulus model uses three parameters **X, Y & Z** to quantify the reflectance from an object in three spectral bands in the 380-780nm range.

- **X** typically correlates predominantly with the "redness" of an object (with some "blueness")
- **Y** typically correlates predominantly with the "greenness" of an object
- **Z** typically correlates predominantly with the "blueness" of an object

Due to the human eye's greater sensitivity to green light, **Y** is sometimes also termed "lightness".

The spectrum associated with each parameter is shown below.

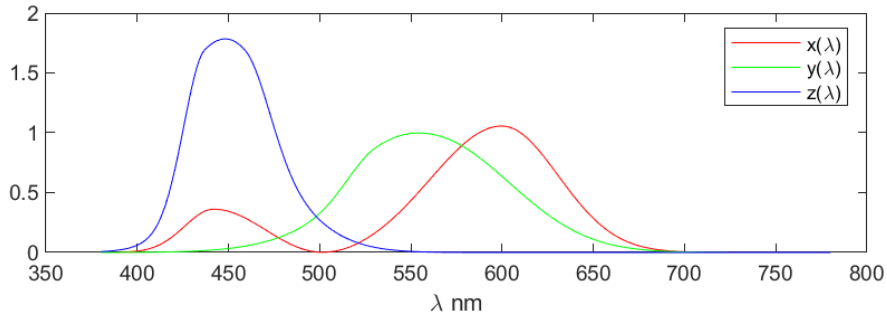


**Figure 1-2 Spectrum associated with X, Y and Z**

**Note:** **X** represents "redness" and "blueness" of the target.

A measurement device can output **X, Y & Z** values for a given sample, which the process operator then uses to determine consistency of colour and if it is within specification (limits).

There are a number of other colour systems that are useful for process control, including **L*, a* and b***, **LCh**, and **ΔE**. All of these are based on the tristimulus model described above. The applicability of these systems in process control settings is discussed in the next section, and the formulae used to calculate these values can be found in Appendix A.

## 1.2 Applicability of Colour Systems to Different Targets

The four measurement systems above vary in their sensitivity, depending on the target's colour and the nature of the variation causing the colour change. It is therefore important for the user to select the most appropriate colour system for their process. This section provides some guidance on what to use when.

### 1.2.1 XYZ

**XYZ** is the most intuitive colour system as it is similar to RGB. As such, **XYZ** (or a subset of this) may be useful in assessing the amount of red, green or blue in a product. For example, paints and dyes (or painted substrates) that vary over a wide range of colours may be well-suited to being measured using the **XYZ** system.

### 1.2.2 L*a*b*

**L*a*b*** is one of the most commonly used colour systems. It is useful for measuring small colour changes in a product and can be found in QC labs and other handheld devices by production lines.

It uses three values to measure colour:

- **L*** represents the lightness of the target (also used for following browning in a product)
- **a*** represents red to green (+**a*** = red and -**a*** = green)
- **b*** represents blue to yellow (+**b*** = yellow and -**b*** = blue)

The **L*a*b*** system for colour perception is very common in the food industry, and in general the following applies:

- **L*** is for measuring very light or dark products that vary over a narrow range of lightness
    - Some operations use this to follow browning, but is inferior to the NDC DOB (Degree of Bake) measurement
- **a*** is a good choice for products that vary in the red-green spectrum
- **b*** is a good choice for products that vary in the blue-yellow spectrum

For example, products that undergo baking may be well-suited to being assessed using **L*** and/or **a***.

### 1.2.3 LCh

These parameters represent the following:

- **L*** represents the lightness of the target
- **C** represents the chroma (or relative saturation)
- **h** represents the hue (or dominant colour)

**Chroma** is best suited to measuring deviations from the colour white – for instance for grading flour or rice – while **hue** is appropriate for natural products that vary in their most dominant colour independently from lightness variation. This is useful for changes in colour intensity or colour dominance in a range of products such as fruit ripening.

### 1.2.4 ∆E

∆**E** is best suited to tolerancing relative to a particular reference or recipe because it tracks the overall change in **L***, **a*** and **b*** from a particular reference point in **L*a*b*** space. This means that the nature of the colour change – in terms of whether it is due to a change in **L***, **a***, **b*** or some combination of the three – will be unknown, but it is a powerful tool to detect a product's overall change in colour. In situations where the change in colour of the product may occur due to change in one single parameter (**L***, **a*** or **b***), it may be preferable to use ∆**L***, ∆**a*** or ∆**b*** independently.

CHAPTER 2

# 2 Installation

## 2.1 Installation Considerations

Install the Series 9 gauge in a location where there is no direct sunlight. The gauge must be mounted at an angle of inclination of 20 degrees to the horizontal (or product line) by tilting the gauge window towards the product line and the cable port at the rear of the gauge away from the product line (Figure 2-1).

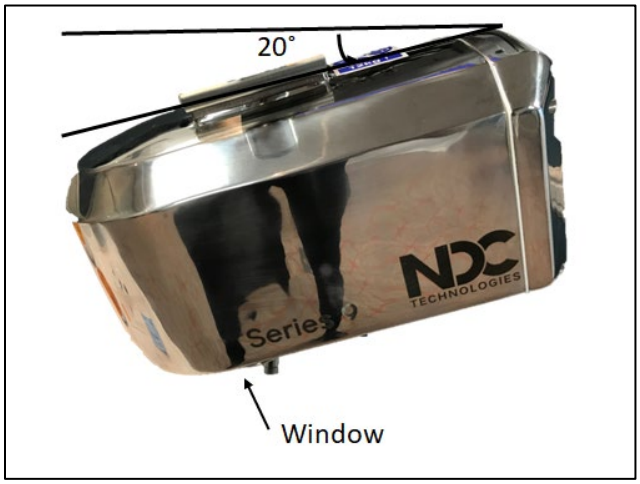


**Figure 2-1 Mount gauge at 20-degree angle**

Refer to Section 4.7 – Installing the Gauge in the Series 9 Full Guide (p/n 120/16549-00) for the beam patch size, height tolerances and instructions on how to position and mount the gauge.

## 2.2 Calibration

The colour measurement is provided with a default factory calibration setting. However, products with different shapes (e.g. flakes vs granules) or different surface finishes (e.g. matt vs gloss) may require different calibration settings to agree with the reference measurement.

## 2.3 Setting Up the Colour Measurement Out of the Box

The setup procedure is as follows:

1. Reference the gauge with a standard if supplied. See Section 7.2.3 – Internal Referencing the Gauge in the Series 9 Full Guide (p/n 120/16549-00).

2. Select the colour system. See Section 3.1 - Selection of Colour Measurement System.

3. Set up a recipe. See Section 3.2.1 - Viewing, Editing and Saving a Product Recipe.

## 2.4 Colour Measurement Outputs

The Colour measurements are shown on the Home page. This page is displayed automatically on power up after the splash screen, as per the example below (Figure 2-2). This example shows the **L***, **C*** and **h*** colour measurements.

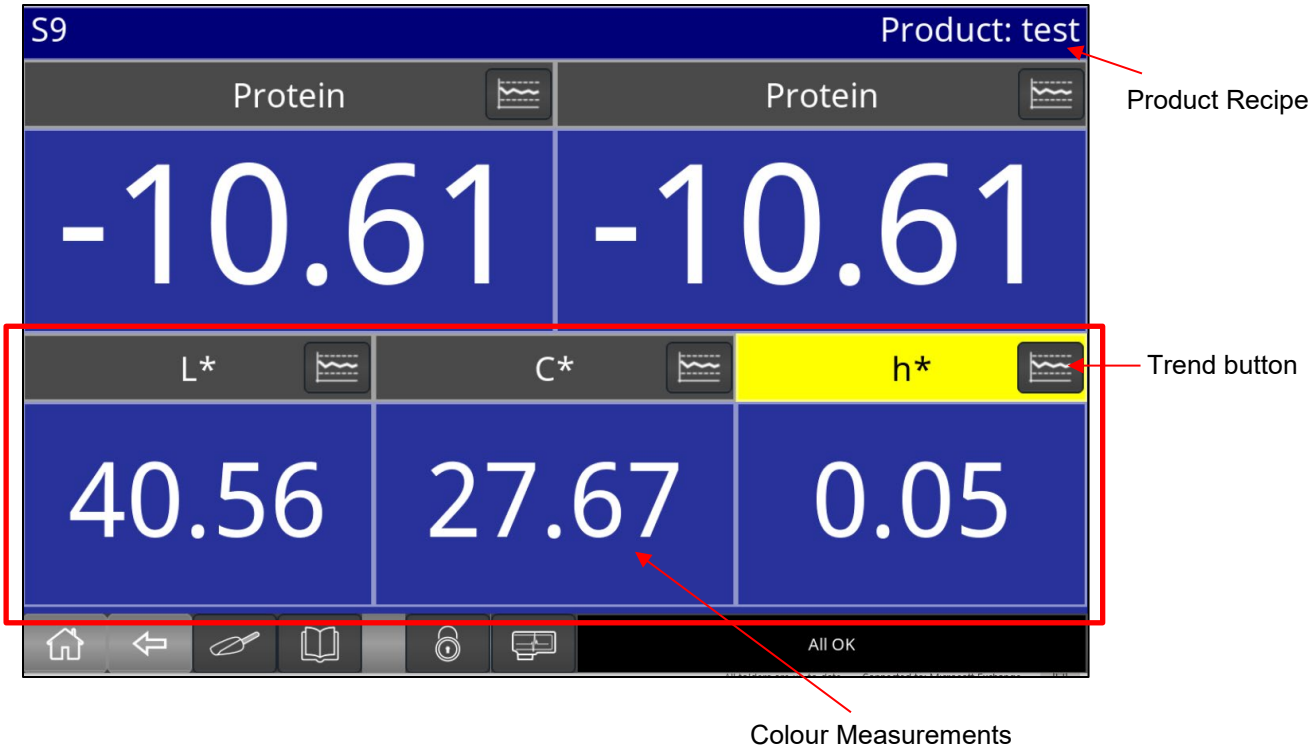


**Figure 2-2 Home page**

Touch the  **Trend** button to display the Trend page (Figure 2-3). The currently selected measurement is shown in the box with a light blue background. Touch the **<** and **>** buttons on the top to scroll through the measurements. To return to the Home page, touch the  **Home** button.

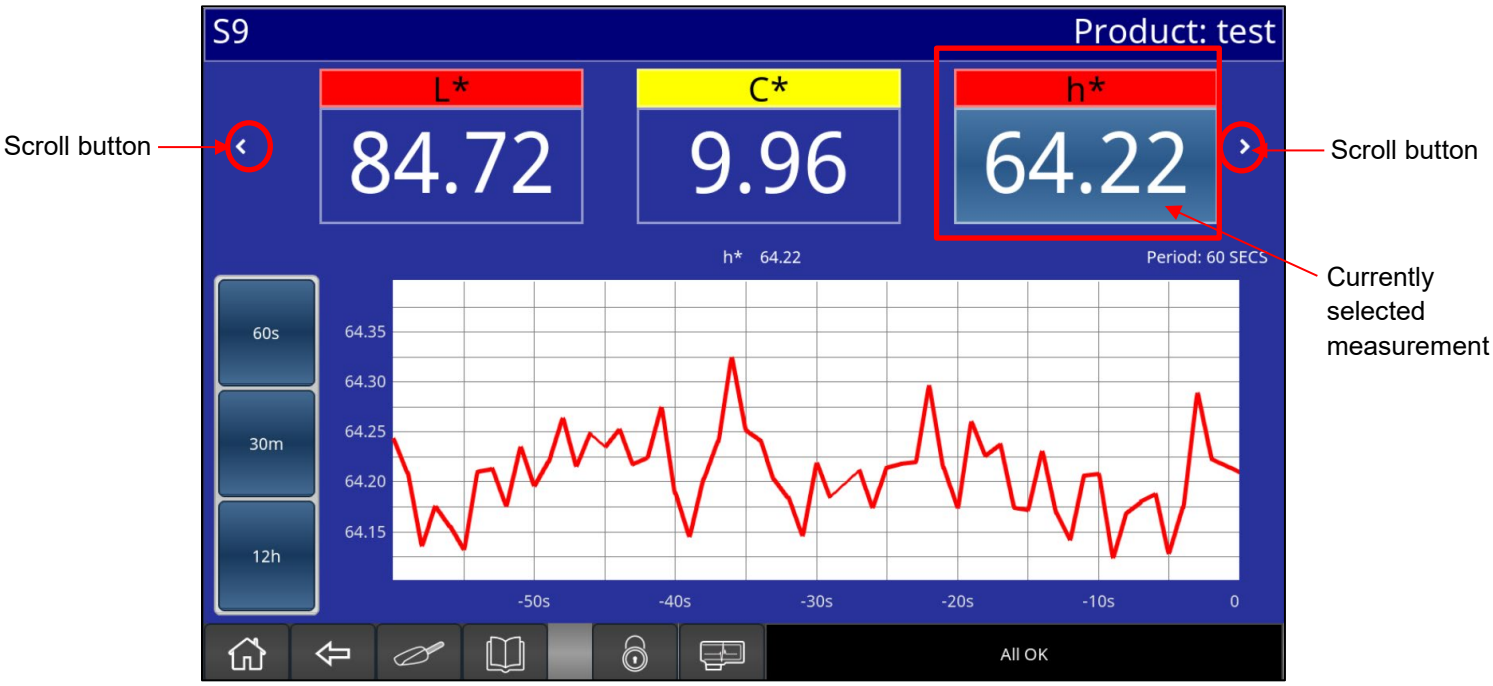


**Figure 2-3 Trend page**

The colour measurements are also shown on the Sample page (Figure 2-4), accessible by touching the

**Sample** button.

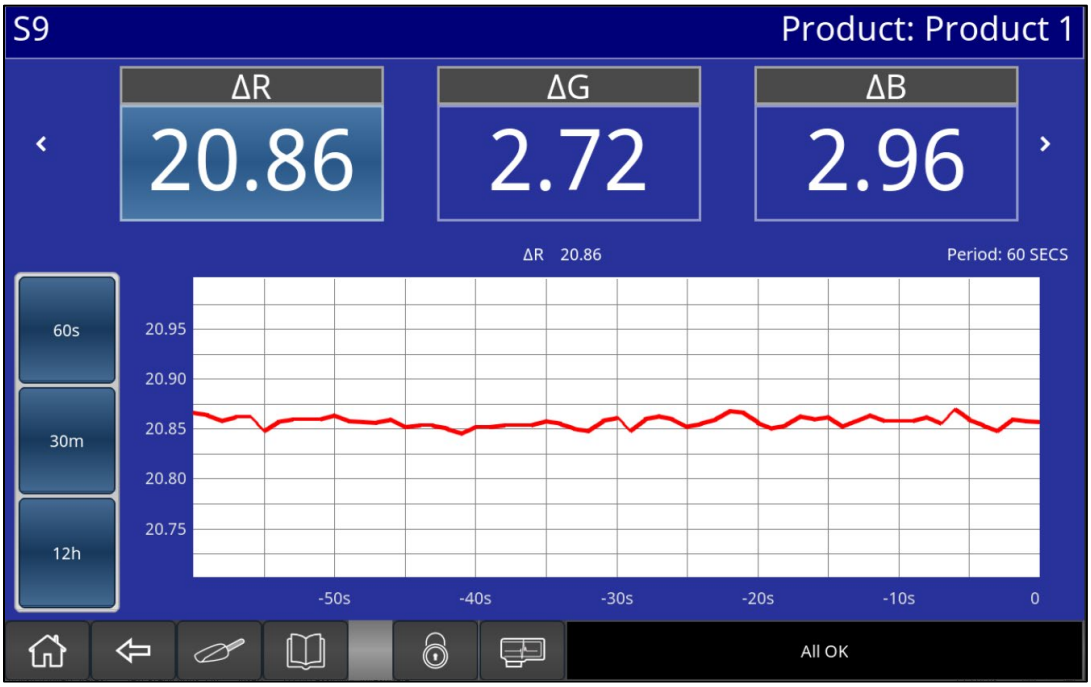


**Figure 2-4 Sample page**

## 2.4.1 Assigning Colour Channels to Analogue Outputs

**Note:** This function is accessible only on the GCI (Gauge Control Interface), and can only be carried out by an Engineer.

If one or two analogue output cards are fitted, two or four analogue outputs will be available from a GCI or GCP (Gauge Control Port). The output type can be 0-10v or 4-20mA - this selection must be matched by the slide switches on the GCI/GCP PCB. See Section 4.9.3.1 – Analogue Output Board in the Series 9 Full Guide (p/n 120/16549-00).

1. Touch the  **Configuration** button to bring up the Settings page.
2. Touch the 

**Hardware Settings** icon.
3. Touch the 

**Analogue Outputs** icon to open the Analog Output Configuration page.

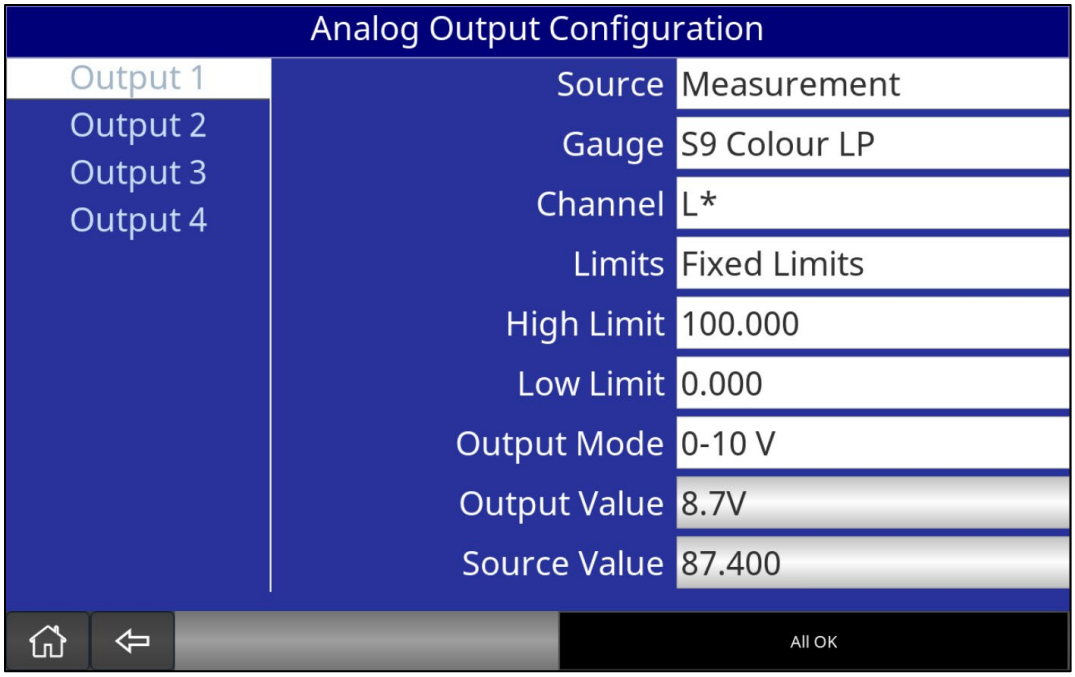


**Figure 2-5 Analog Output Configuration page**

4. Figure 2-5 shows two analogue output cards fitted, giving 4 outputs to the colour measurement channel as required.

   Select an Output from the left pane (e.g., Output 1).

5. Touch the **Source** box and select **Measurement** as the source of the analogue output.

6. Touch the **Gauge** box and select a gauge.

7. Touch the **Channel** box and select the colour measurement channel to be assigned to the output.

   The choices for the colour channels will be displayed. Figure 2-6 shows an example of the colour channels that can be selected, which are L*, a* and b*.

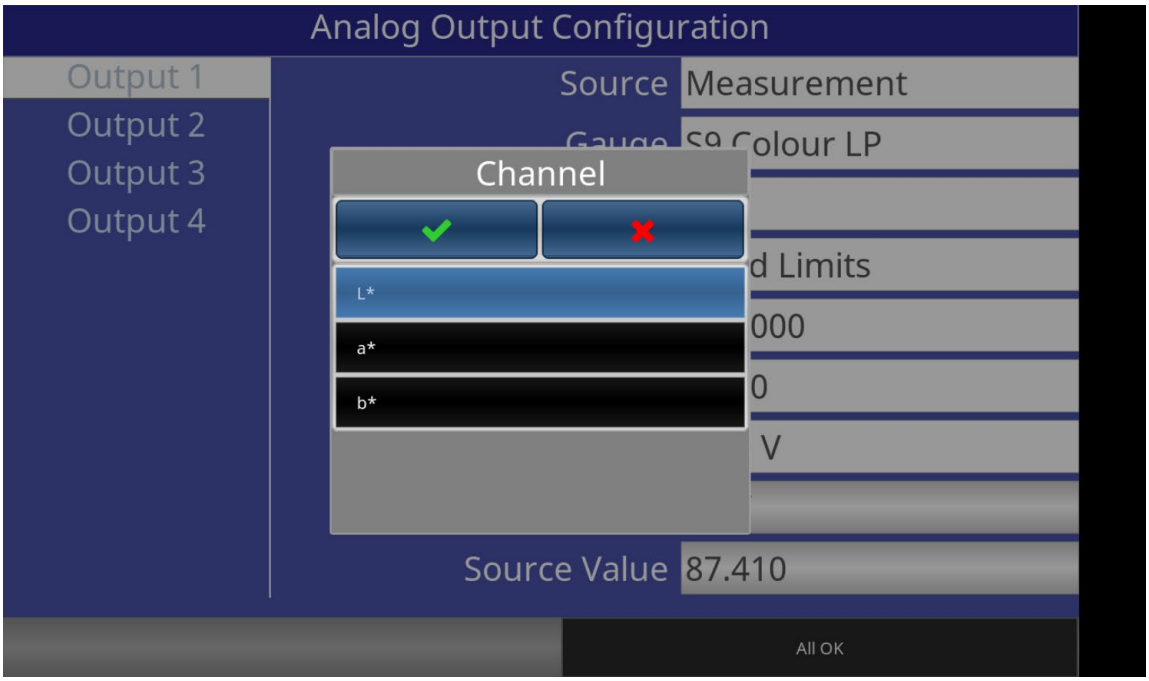


**Figure 2-6 Colour Channel choices**

In Figure 2-5, Output 1 has been assigned to colour measurement channel L*.

8. Leave the **Limits** box entry at **Fixed Limits**. This option allows you to set the low and high measurement values manually. It provides a voltage or current output that is directly proportional to the analogue output source.

9. Set **High Limit** to the colour measurement value corresponding to the maximum voltage or current from the analogue output.

10. Set **Low Limit** to the colour measurement value corresponding to the minimum voltage or current from the analogue output.

11. Touch the **Output Mode** box and select the analogue output: 0-10 V or 4-20 ma.

12. The **Output Value** box continuously updates to show the current value of the analogue output in V or mA. The **Source Value** box continuously updates to show the current value of the source of the analogue output.

    (These boxes are shown in a lightly shaded grey background to indicate that they are not touchable boxes.)

CHAPTER 3

# 3 Operation

## 3.1 Selection of Colour Measurement System

The colour measurement system is selected in a product recipe. In addition to the Colour Space and Measurement settings, there are settings associated with each colour measurement channel.
See Section 3.2.1 - Viewing, Editing and Saving a Product Recipe,

## 3.2 Product Recipes

### 3.2.1 Viewing, Editing and Saving a Product Recipe

This function is only accessible to a Supervisor or Engineer.

To view or edit the contents of a Product Recipe:

1. Touch the  **Configuration** button to bring up the Settings page.
2. Touch the 

**Configure Products** icon.

   The Configure Products page will appear (Figure 3-1).


**Figure 3-1 Configure Products page**

3. Under “Select Product”, select a Product from the list.

4. Touch the **Edit** button.

5. Select **Colour** from the left pane (Figure 3-2).

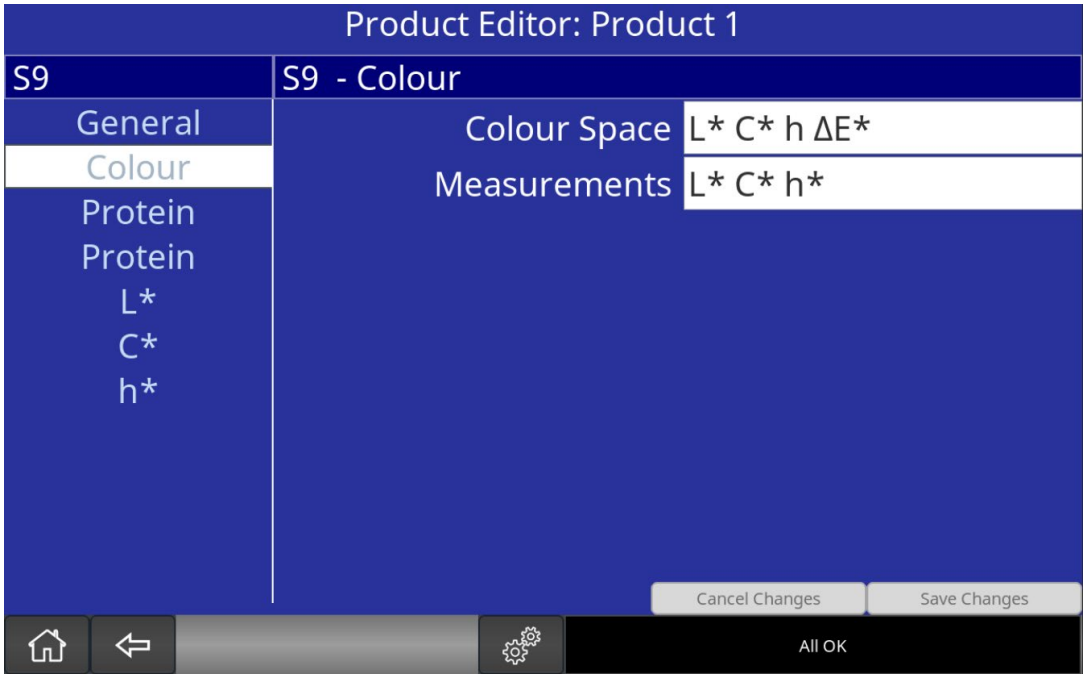


**Figure 3-2 Colour Space and Measurement settings**

6. Touch the **Colour Space** box and select a colour system.
   Available choices include **L* a* b* ΔE***, **L* a* b* ΔEcmc**, **L* C* h ΔE***, **L a b ΔE**, **X Y Z** and **R G B**.

7. Touch the **Measurements** box and select the measurements to be shown on the Home page (Figure 2-2), Trend page (Figure 2-3) and Sample page (Figure 2-4).

8. Select a colour measurement channel from the left pane. The settings associated with the selected channel will be displayed on the right (Figure 3-3). Simply swipe up or down to scroll the settings.


**Figure 3-3 Settings associated with selected colour channel**

9. To change a setting, touch the appropriate box and enter the new value or select from the list shown.

   If a setting is changed, the affected box will be shown with a light yellow background (Figure 3-4) until the change is saved or discarded.

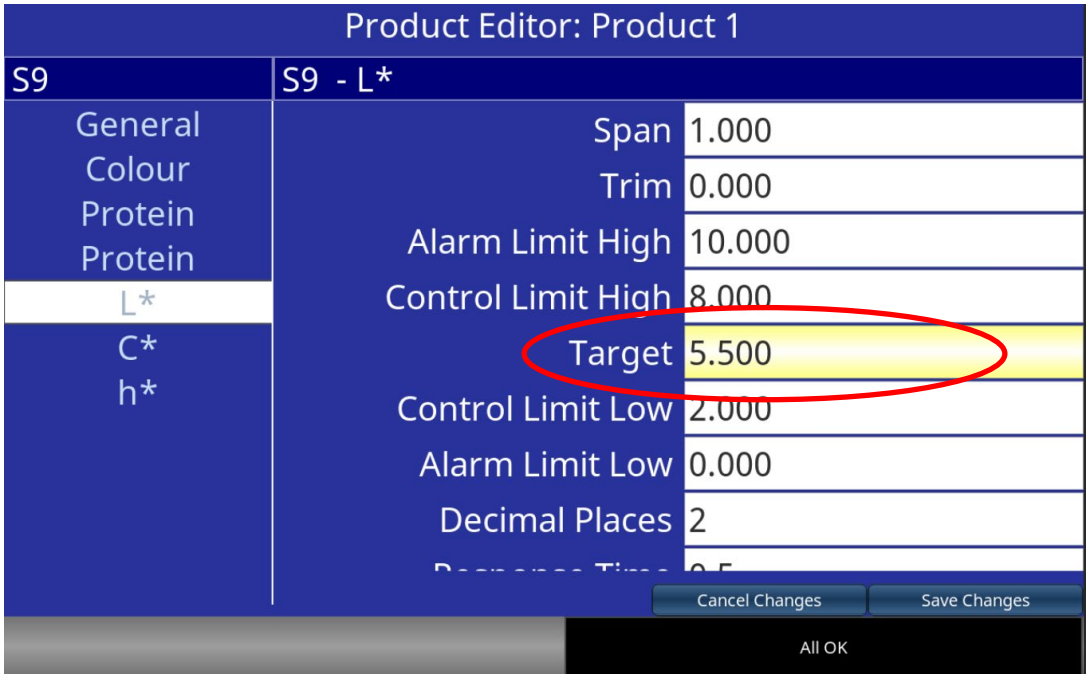


**Figure 3-4 Product change indicator**

10. To save the changes to the Product, touch the **Save Changes** button.
    Otherwise, if the **Cancel Changes** button is touched, the changes will not be saved to the Product.
    Note that the change will not take effect on the current measurement until loaded.

## 3.2.2 Loading a Product

This function can be used recall a selected product in the system gauge. When this is done, the values stored in the product become the current gauge values for making measurements. They are also the values that will be modified by any changes made through the **Edit Product** function or through calibration adjustments.

1. Touch the  **Product Selection** button to open the Load Product page.

   Alternatively, bring up the Configure Products page (Figure 3-1):

    **Configuration** > 
   
   **Configure Products**

2. Select the relevant product from the list.

3. Touch the **Load** button.

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CHAPTER
4

# 4 Diagnostics

## 4.1 Using the External White Colour Standard to Re-reference and Check the Gauge

The colour option is supplied with an external white reference standard which is used to re-reference the gauge as well as a measurement confidence check. The standard is supplied in a black canister with a bayonet fit and is used with an adapter.

Photos and part numbers for these items are given in Figure 4-1:

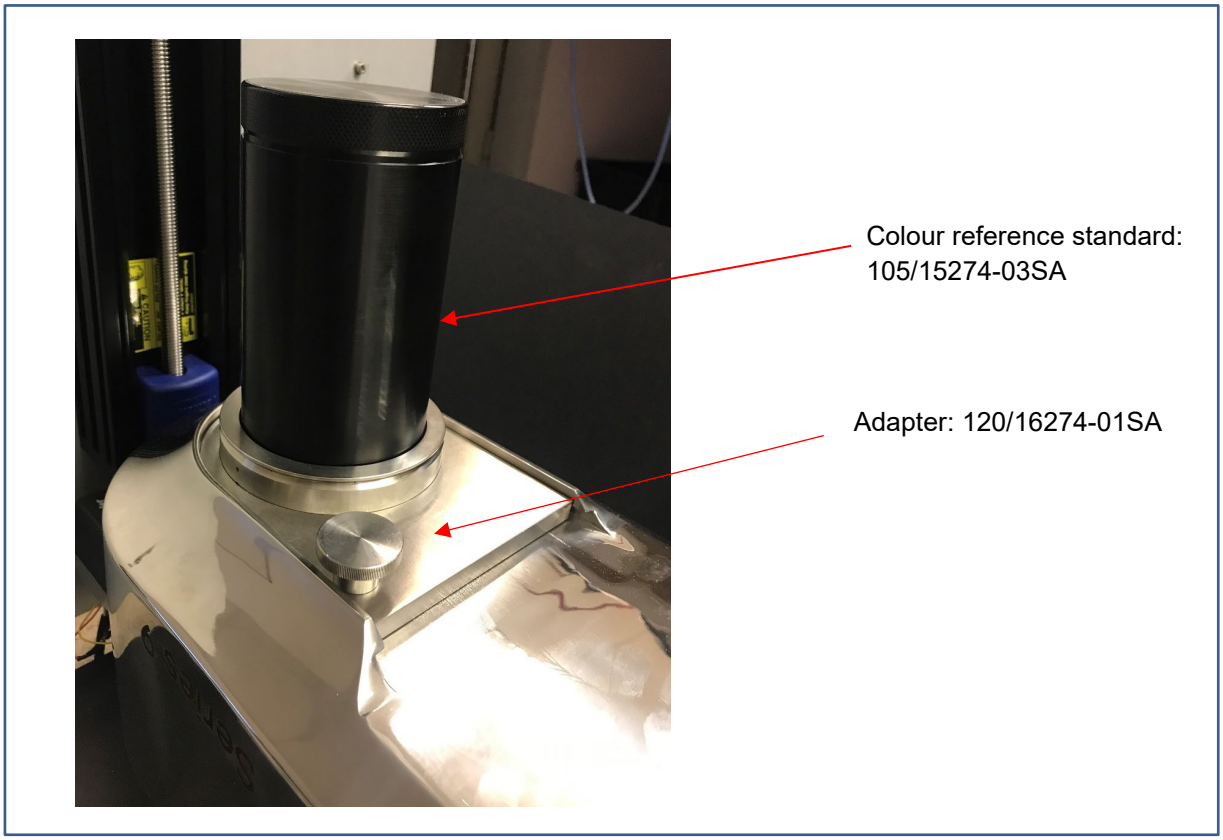


**Figure 4-1 Colour reference standard and Adapter**

The adapter is slid in place and locked by tightening the large locking screw clockwise. The reference standard has a bayonet type fit using pins that locate into slots in the adapter which are colour coded yellow and red to aid with the initial alignment, as shown in Figure 4-2. Rotate the standard fully clockwise to lock it in place.

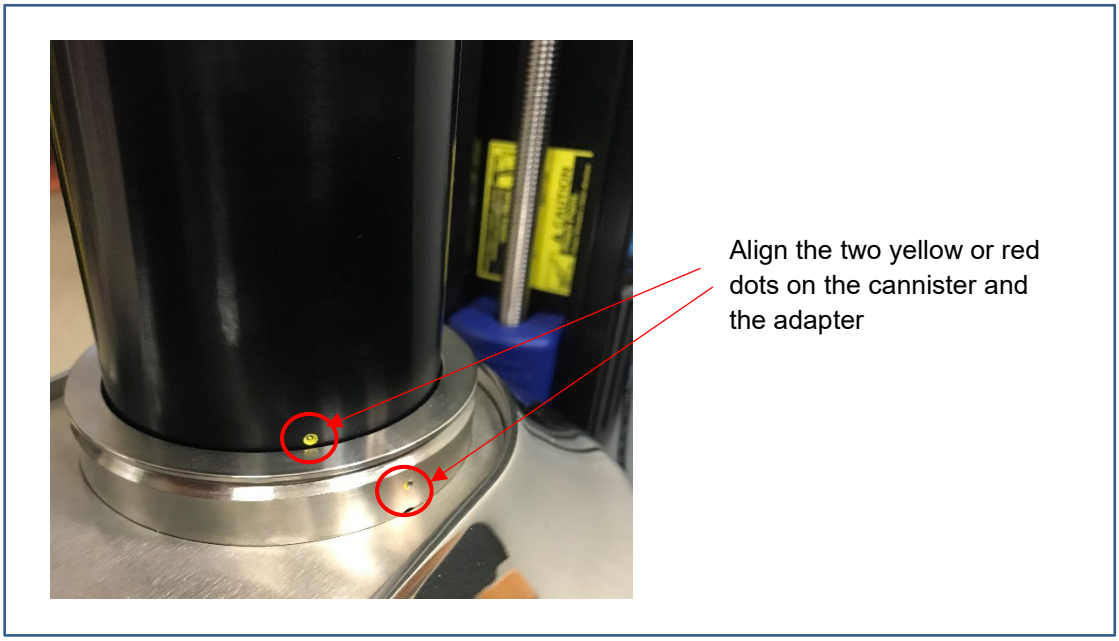


**Figure 4-2 Align dots on canister and adapter**

The reading with the standard on the colour channels of the gauge will depend on the calibration used, but will be within the ranges stated below for the initial factory calibration:

**L* = 80–88**

**a* = 1–3**

**b* = 7–9**

The exact values are not important, but as a stability check, take a note of the initial values after the gauge has been first installed and left running for a few hours using a fixed reference calibration, and then compare these against subsequent readings to check that they remain approximately the same.

If the values vary significantly, check that the gauge window is clean and if necessary, re-reference the gauge.

## 4.1.1 Re-referencing

Note that **re-referencing the colour measurement can only be done using the external reference standard supplied with the gauge (not the internal reference)** and acts on both the raw IR and colour signal to bring them both back to a known factory state.

Re-referencing is usually only conducted after a lamp change, using the **Re-Reference** button shown below (Figure 4-3):

1. Touch the  **Configuration** button, and then touch 

**Gauge Diagnostics** on the Settings page.

2. Touch the  **Check** button to bring up the Gauge/Reference Check page.

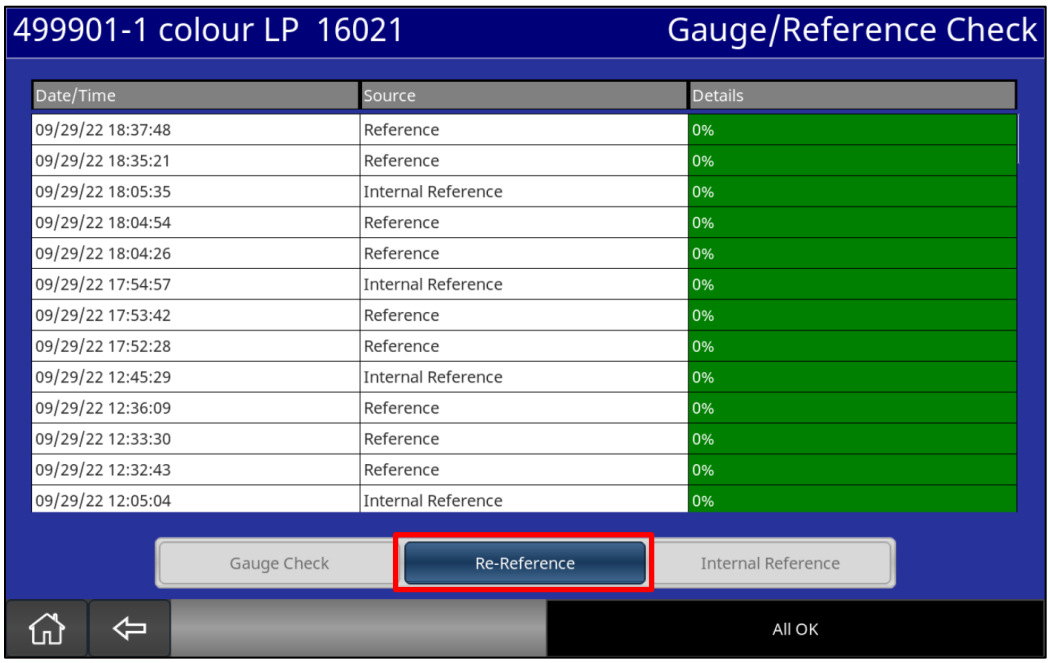


**Figure 4-3 Re-Reference button**

Note that the fitting of the external reference standard is automatically sensed by the gauge and the **Re-Reference** button will be greyed out, if not fitted.

## 4.2 Servicing Requirements

Depending on usage, the lamp may need to be changed as needed. Refer to Section 8.3 – Replacing the Gauge Source Lamp Assembly in the Series 9 Full Guide (p/n 120/16549-00) for instructions on how to replace the lamp.

CHAPTER
5

# 5 Servicing, Returns and Recycling

## 5.1 Servicing and Returning your Equipment

Your instrument was carefully inspected electrically and mechanically prior to shipment. It should be free of surface defects and scratches, and it should be in perfect working order upon receipt. If any indication of damage is found, file a claim with the carrier immediately, prior to using the instrument. If no damage is apparent, proceed by using this manual to install and setup this instrument.

Save the shipping carton and packing material for future storing or shipment of the instrument. If, at some future time, the instrument must be returned to the factory for service, include a full description of the instrument failure and the mode of operation the instrument was in at the time of failure. Also include a contact person to discuss the instrument failure.

When returning equipment for service, it is important to first obtain a Return Material Authorization (RMA) number. The RMA number is needed for proper handling of returned equipment.

- To obtain an RMA, go to https://ndc.custhelp.com/.
- To create a myNDC account, click the **Log in or Sign up** button. After creating the account, you will be immediately logged in. To log in on subsequent visits to myNDC, click the **Log in or Sign up** button, enter your username and password, and then click **Log in**.
- To submit an RMA, click on the **RMA Request** link and follow the on-screen instructions.

Ship the instrument in the original carton, or, if the original carton is unavailable, ship in a carton providing sufficient protection. Send the instrument to the Asia, Europe, or USA office, whichever is closest to you or to the office indicated by your sales engineer. Place the RMA number on the outside of the carton and include a purchase order number and any other information specific to your instrument. Field warranty service is available if the customer pays travel expenses by advance purchase order. All service operations should be performed by skilled electronics technicians, who have been trained by NDC Technologies.

## 5.2 Recycling, Disposal and Sustainability

NDC Technologies provides intelligent measurement and control solutions to help you focus on your unique mission in a more sustainable way. Better for your people. Better for your bottom line. Better for the planet. For this reason, NDC Technologies encourages its customers to recycle and dispose of equipment in a way which is responsible and encourages sustainability.

Please check the following before disposing of your equipment:

- Is the equipment worth repairing? If in doubt, contact NDC Service.
- If you are aware of any hazardous materials in your equipment, ensure qualified personnel take responsibility for its disposal. Some examples of hazardous substances include lead, mercury, cadmium, chromium VI, flame retardants, plasticizers, fluorescent tubes, monitors containing cathode ray tubes and products containing capacitors. NDC is compliant with the European WEEE and the most current RoHS Directive.
- Can you re-use or recycle any constituent parts? For example, if the housing/chassis is made of metal, it can be recycled by your local authority. Ensure qualified personnel take responsibility for dismantling the equipment.

If the equipment does need to be disposed of, please dispose of it in a way that does not harm the environment.

APPENDIX

A

# Colour Systems Formulae

## ΔE

Devices that output multiple values can be confusing to certain process operations, and it can be beneficial to combine the three values into a single value that reports a quantifiable change in appearance of the product compared to a reference sample. One such approach is to combine the **L***, **a*** and **b*** values as below and calculate Δ**E**:

$$\Delta E = \sqrt[2]{(L_t^* - L_r^*)^2 + (a_t^* - a_r^*)^2 + (b_t^* - b_t^r)^2}$$

Δ**E** essentially measures the (Euclidean) distance in colour space between the target, **t**, and some reference colour, **r**. However, it does not inform the operator what the nature of the colour change is. Additionally, a ΔE of less than 2.3 units will be imperceptible to the operator.

## ΔL*, Δa*, Δb*

These parameters quantify the variation in **L***, **a***, or **b*** of the target, **t**, relative to some reference colour, **r**:

$$\Delta L^* = |L_t^* - L_r^*|$$

$$\Delta a^* = |a_t^* - a_r^*|$$

$$\Delta b^* = |b_t^* - b_r^*|$$

This can be more useful for determining the changes compared to a reference standard in the lightness, green to red and blue to yellow in a product. Limits can be setup in the device that report when a product is out of specification.

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# Warranty

1. All sales of NDC Technologies products are subject to the contractual terms and conditions of the Order pursuant to which they were sold to Buyer, including Warranty terms. The following terms are a general summary of the contractual Warranty terms, NOT a revision or alternative to the contractual terms, and are presented as merely a point of reference for your information. The contractual Warranty is the complete and exclusive statement of all NDC Technologies warranties to Buyer. In the event the following terms are in conflict with any of the contractual Warranty terms, the contractual Warranty terms shall be deemed to control.

   **The warranty terms contained herein are expressly in lieu of any and all other warranties, expressed or implied, including any warranty of merchantability or fitness for a particular purpose. In no event shall NDC Technologies be liable for any incidental, consequential or special damages, including but not limited to, any loss of business, income or profits, expenses incurred for time when the system is not in operation, and any labor costs relating to or arising out of the performance, functioning or use of the system.**

   **Purchaser assumes the risk for use of this product and agrees to indemnify and hold NDC Technologies harmless for any and all damage to person or to property resulting therefrom.**

   **NDC Technologies grants no license under any patent rights except the right, under only such patents as may be owned or acquired by NDC Technologies, to use the product sold hereby for the purpose for which it is sold. NDC Technologies does not warrant that the product or its use does not infringe any patent owned by persons other than NDC Technologies.**

2. NDC Technologies guarantees all products to be free from defects in material and workmanship for the following periods[1]:

   - Product and peripherals – 2 years from shipment
   - Source lamp – 5 years from shipment
   - Filter wheel motor – 5 years from shipment
   - Spare parts – 1 year from shipment
   - Replacement lamps and motors supplied under warranty – 1 year or up to the original 5 year warranty from shipment of the sensor, whichever is longer

   [1] Refer to the contractual terms and conditions of the Order for usage of the warranty.

   During this period, NDC Technologies will repair or at its option replace, free of all charges for parts and labor, any NDC Technologies parts determined by it to have been broken or damaged due to causes other than improper application, abuse or negligence. NDC Technologies' obligation to repair or replace shall not extend to expendable parts which are subject to normal operating wear.

   Nothing in this paragraph 2 will require NDC Technologies to make repairs or replacements where:

A. The product has been repaired, other than by an authorized NDC Technologies dealer or an NDC Technologies employee, or altered in any way without the prior written consent of NDC Technologies; or

B. The product has not been properly maintained in accordance with any operating and maintenance manual supplied therewith; or

C. The product has been damaged as a result of fire, flood, war, insurrection, civil commotion, acts of God or any other cause beyond the control of NDC Technologies or Buyer.

3. NDC Technologies' liability shall be limited to the obligations set forth in Paragraph 2. These shall be the Buyer's sole and exclusive remedies, whether in contract, tort or otherwise, provided, however, that in lieu thereof, NDC Technologies at its option may replace the entire product on an exchange basis or refund the purchase price against the return of the defective product.

4. NDC Technologies will not be responsible for failure to provide service or parts due to shortage of materials, labor or transportation strikes or delays, or any causes beyond NDC Technologies' control.

5. Unless otherwise specified by NDC Technologies, all warranty repairs will be made at NDC Technologies' facility. The customer shall be responsible for all expenses of packing, freight and insurance in connection with the shipment of products to NDC Technologies for repair. NDC Technologies will pay the cost of returning the equipment to customer.

   **If it is mutually determined by the buyer and NDC Technologies that the examination, replacement or repair takes place at the buyer's facility, then the buyer will be responsible for NDC Technologies' travel and living expenses incurred in traveling to and from the buyer's facility, and during the time of the visit, as well as the cost of field labor and replacement parts unless the parts being repaired or replaced are determined to have been defective, in which event the cost of said repaired or replacement parts shall be borne by NDC Technologies. These travel and living expenses will be billed to the buyer at actual cost to NDC Technologies.**

6. No person, including any NDC Technologies distributor, agent or representative, is authorized to assume any liability on behalf or in the name of NDC Technologies, and NDC Technologies shall not be bound to any understandings, representations, or agreements with respect to warranties except as set forth in this policy.

7. NDC Technologies requests immediate notification of any claims arising from damage in transit in order to determine if carrier responsibility exists. If damaged equipment arrives, save the shipping container for inspection by the carrier and telephone NDC Technologies as soon as possible.