

Hybrid Ceramic Disc Alignment

~ Requirements for supporting software ~

Requirements Discussion Document for Phase 1

Revision 1 - Document 02/12/2020 by Jonathan Markland

# Purpose

The purpose of this document is to establish the Phase 1 requirements for some software at Waters Solihull, UK, to assist in the identification of suitable pairings of mass spectrometer parts known as “Alignment Discs”. Alignment Discs are brackets that hold the four poles of the quadrupole together.

# Background

*Note: A more comprehensive manufacturing-oriented background can be obtained from Dale Beardsall. This section presents a software perspective.*

Alignment Discs are manufactured by Waters, and then measured at Solihull by an operator using a CMM machine (TODO: Get proper name?).

Per disc, sixteen measured values are taken, falling into three categories:

* 4 x Flatness measurements
* 4 x Parallelism measurements
* 8 x Diagonal Distance measurements

After a disc has been measured, its Flatness and Parallelism measurements are inspected. If they fall outside permitted tolerances, the disc is outright rejected. Otherwise, two tolerance bands are established, Grade A and Grade B. Grade B components cannot go into high-end instruments. Grade A are suitable for both.

After passing Parallelism and Flatness criteria, the Alignment Disc then needs to be paired with a suitable partner and, as a pair, they hold in place the four quadrupole rods of a mass spectrometer.

As a result of extremely high tolerance needs, suitable pairs are defined as those discs that have the most similar Diagonal Distance measurements.

## Hackathon 2020

*Dale Beardsall commissioned a Hackathon effort in 2020, and was joined by Louis Goldsby (Manufacturing), Jonathan Markland (Software) and Angela Beesley (Mathematics).*

Louis provided Measurement Files from the CMM machine, of various discs.

Angela provided mathematical modelling for the pairing algorithm where the 8 Diagonal Distance measurements of one disc are compared with the respective 8 Diagonal Distance measurements of a second disc using the Euclidean Distance technique.

Jonathan developed software to read the data files emitted by the CMM machine, and to extract from these the 16 measurement values, and the unique Serial Number of the Alignment Disc. This included an implementation of Angela’s mathematics. The mathematical output is a list of pairs, in order of closest match.

The project was voted winner of the Hackathon for this year.

## Post-Hackathon

The completed hackathon left some completed C# code, including a file reader, a mathematics implementation, and a Unit Test framework, that could be used in the final software.

There was, however, no software in a form suitable for the manufacturing team to “just use”.

# Problem Statement

## Manual Process

The operator at Solihull will measure Batches of Alignment Discs manually, using the CMM machine.

For each Alignment Disc there is an output Measurement Text File, which the operator will save into a Batch Folder using the menus in the CMM software.

*Since the Measurement Text File is to be read by software, there should be no need for the operator to examine these files, but they can if desired.*

After all measurements are taken, the Batch Folder will contain all the Measurement Text Files for all desired Alignment Discs.

## Software Process

The operator then desires to active a new piece of software (TODO: name it!) (to be established by this specification) which will:

* Examine all the Measurement Text Files in the Batch Folder
* Produce a Measurement Report (defined below)
* Move the files of all successfully paired discs from the Batch Folder to a Success Folder
* Move any files that could not be read at all to an Error Folder, for examination by IT Support
* Leave the residual files of unsuccessful pairings in the Batch Folder for the next batch

## Measurement Report

The Measurement Report is a single HTML file that is given an automatic name with the time and date, saved into a Reports folder.

The file comprises:

### Summary Section

The summary information includes:

* The Date and Time at which the pairing software was run (NB: Does not need to be the same day as the measurements).
* File Count: The total number of files in the Batch Folder at the time of processing
* Disc Count: The total number of discs positively identified from those files
* Error File Count: The number of “Error” files that could not be read at all. These are not identifiable as Measurement Text Files.
* Pair Count: The number of pairs successfully obtained, and of those, how many were grade A-A, how many A-B, how many grade B-B
* Grade A Count: The number of discs in Overall Grade A
* Grade B Count: The number of discs in Overall Grade B
* Grade Fail Count: The number of discs that passed Flatness and Parallelism but failed the grades
* Rejection Count: The number of discs that failed Flatness or Parallelism

### Section 1: Successful Pairings Summary

For each successful pair (#1, #2), a list of:

* Alignment Disc Serial Number for Disc #1
* Measurement Text File name for Disc #1
* Overall grade for Disc #1
* Alignment Disc Serial Number for Disc #2
* Measurement Text File name for Disc #2
* Overall grade for Disc #2

### Section 2: Discs Detail

Then underneath, a list of the details for each Alignment Disc, including:

* Alignment Disc Serial Number
* Measurement Text File name
* The overall grade
* The 4 x Flatness measurements, including grade
* The 4 x Parallelism measurements, including grade
* The 8 x Diagonal Distance measurements, including grade

This list is in order of Serial Number.

### Section 3: Failed Files

This is simply a list of the file names of any files that were in the Batch Folder that the software could not read and, as such, they cannot be identified as Alignment Discs.