Technical Report					
Title:	**CCII 00024 Report for Friedr Freek QFE Arrays**				
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Introduction

This report describes a range of experiments carried out on QFE type elements mounted in a 3 x 3 array. The array is first tested with all elements powered on. Using the Herschel (robotised 3D Heat Flux scanning unit), a full temperature scan of the element surface is performed followed by a 2D heat flux scan at a distance of 100mm from the array surface. Two simple reflector lengths are also trialled (20mm and 50mm) and again scanned at a distance of 100mm using the Herschel.

Next, single elements within the array are powered off to simulate a broken or faulty QFE element. The array is again scanned using the Herschel in a 2D scan. Finally, the effect of fitting a surrounding reflector is investigated. Two simple reflector lengths are trialled (20mm and 50mm) and again scanned at a distance of 100mm using the Herschel. In each case, the simple reflectors (20mm and 50mm) are fitted and again scanned at a distance of 100mm using the Herschel.

Table 1: List of Elements tested

Test Number	Unpowered Element No.	Power (W)	reflector
1	-	1350	no reflector
2	1	1200	no reflector
3	2	1200	no reflector
4	5	1200	no reflector
5	-	1350	(a) 20 mm
6	1	1200	(a) 20 mm
7	2	1200	(a) 20 mm
8	5	1200	(a) 20 mm
9	-	1350	(b) 50 mm
10	1	1200	(b) 50 mm
11	2	1200	(b) 50 mm
12	5	1200	(b) 50 mm


No reflector 20mm reflector 50mm reflector

Figure 1: 3x3 QFE 150W array with reflectors

A view of the elements in the array and the surrounding reflectors are shown in Figure 1. The array was mounted on a backing of three aluminised steel rails and measured 190 x 190mm. The reflector was a simple square of aluminised steel measuring 215 x 215mm fitted around the array. One reflector had a depth of 20mm and the other a depth of 50mm measured from the aluminised steel rails.

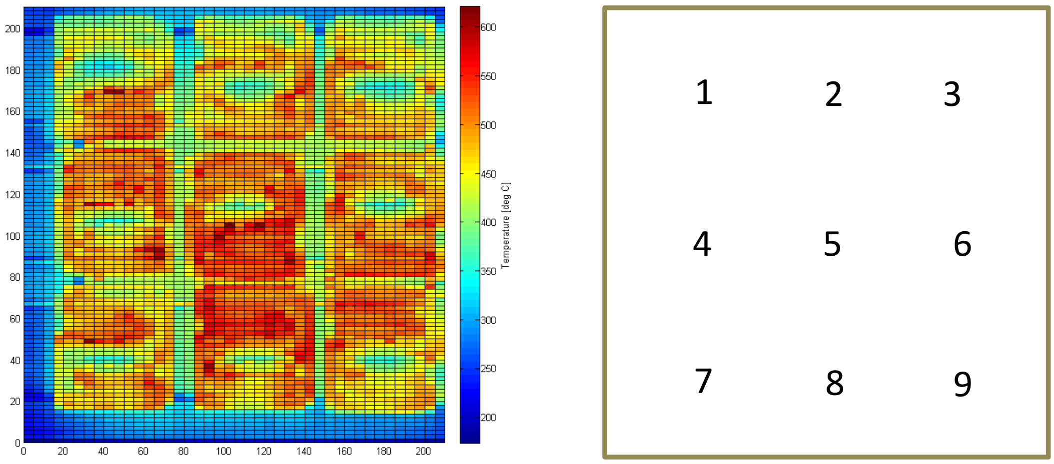

Figure 2: 2D Temperature scan of QFE Array and element numbering scheme.

A temperature scan and element numbering scheme of the array is shown in Figure 2. The temperature was recorded using a non-contact infrared thermocouple with a spot size of 1.5mm at a distance of 450mm. This way, a thermographic image of reasonable resolution was composed. All elements were powered on for this scan, each element is 150W therefore giving a total of 1350W. No reflector was fitted around the outside of the array in this test.

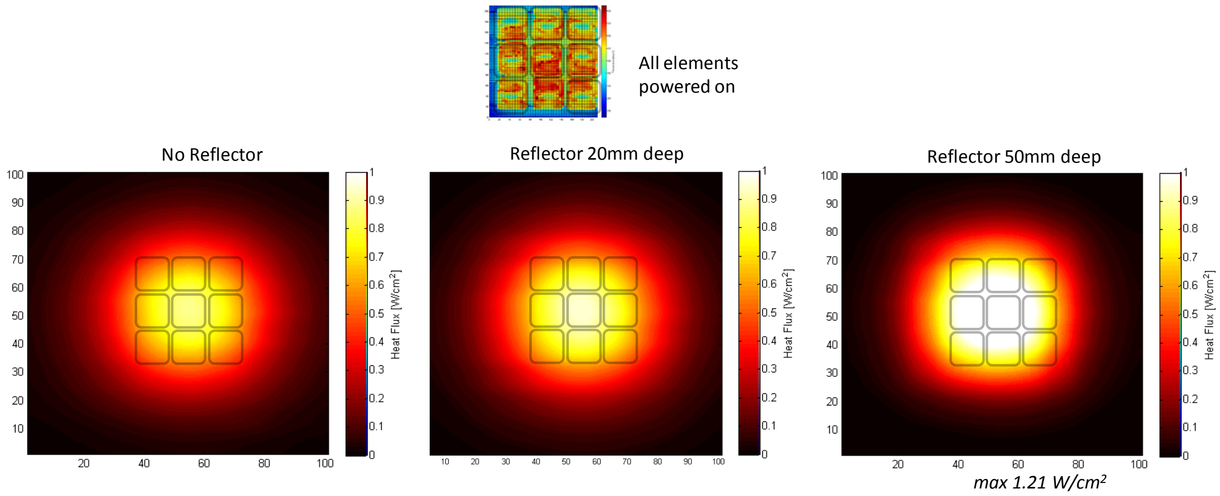

Figure 3: 2D Heat flux at 100mm, all elements powered on (1350W)

The results of the first test are shown in Figure 3. The first image shows a generally circular heat flux profile emanating from the array with the strongest peak at the centre. Maximum heat flux without a reflector in this case was 0.89 W/cm^2. The heat flux weakens gradually with distance from the centre. The second image shows the heat flux from the same array with a square reflector of 20mm depth around the array. The heat flux profile is not as circular and the influence of the square shaped reflector can be seen in the profile contours. Peak heat flux increased to 0.96 W/cm^2 by the addition of this reflector. The last image shows the effect of adding a 50mm reflector. The heat flux contours are visibly much more influenced by the shape of the reflector tending towards a more square profile. Dispersion or scattering of the radiant emission is much less than with either “non reflector” or 20mm reflector cases. The radiant heat flux is much more confined as a result of the 50mm reflector and maximum heat flux recorded was 1.21 W/cm^2.

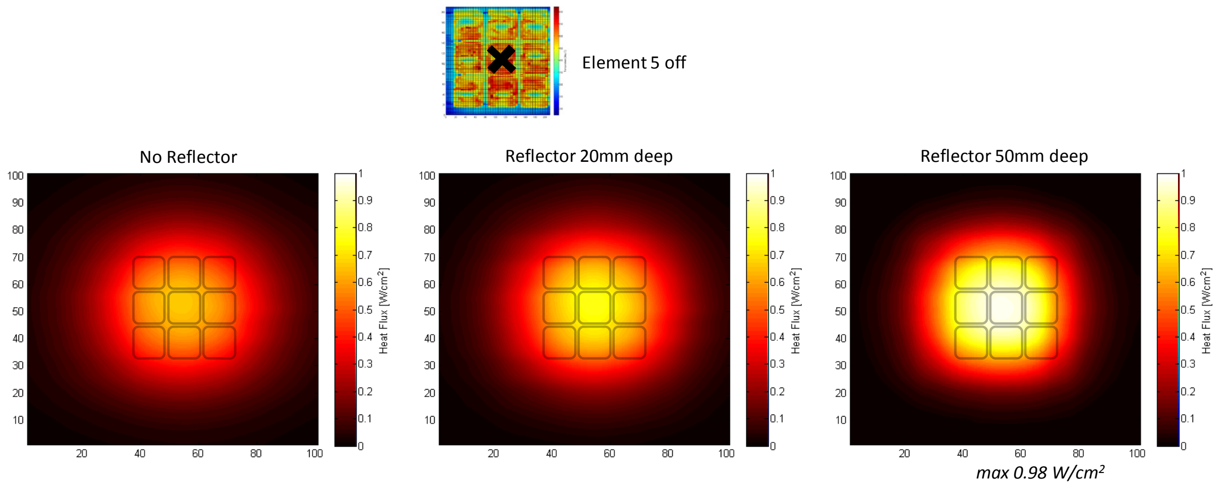

Figure 4: 2D Heat flux at 100mm, element 5 powered off (1200W)

In the second test, the central element in the array (no. 5) was powered off. The power level is therefore reduced from 1350W to 1200W accordingly. The 2D heat scans are shown in Figure 4. In the case of no reflector, the heat flux is visibly reduced when compared with the 1350W case in Figure 3. Maximum heat flux occurred at the centre and has decreased from 0.89 W/cm^2 to 0.66 W/cm^2. However, the wide colour bands indicate a more uniform heat flux field as a result of switching off the central element where the heat is now provided by the eight peripheral elements. As an aside, it must be noted that although the central element is unpowered, it will be heated by the other elements and therefore will still emit radiant heat. When the 20mm reflector is added, the maximum heat flux does increase to 0.77 W/cm^2 and the radiative dispersion is notably less than with no reflector. Finally, in the last case with the 50mm reflector, the dispersion is appreciably lessened as witnessed by the darker areas around the fringe of the plot. The peak heat flux has also increased to 0.98 W/cm^2. In general, the centre element being switched off results in a flatter heat flux field. This is very apparent in the centre region of the first image in Figure 4.

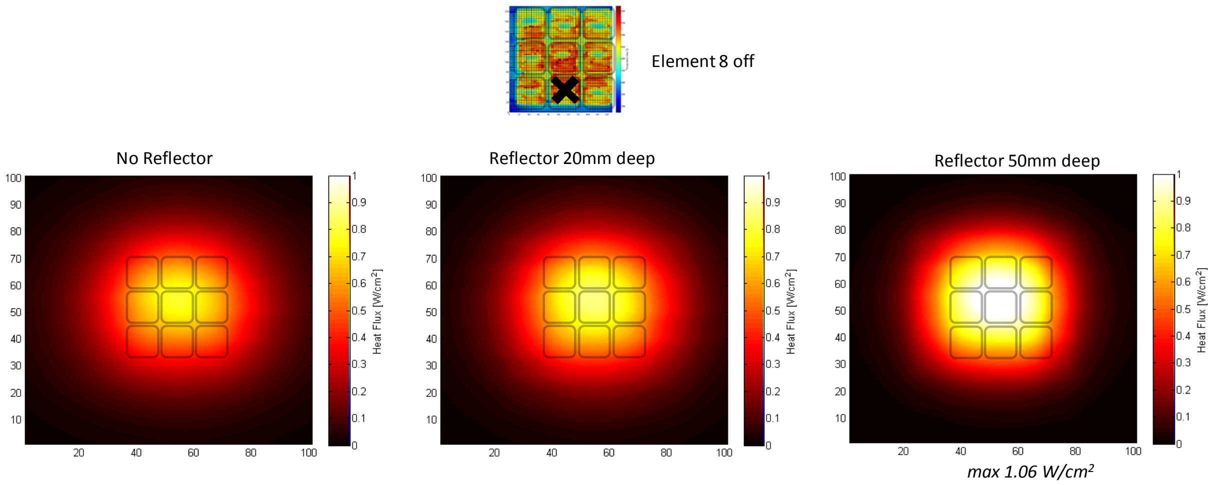

Figure 5: 2D Heat flux at 100mm, element 8 powered off (1200W)

In the third test shown in Figure 5, element 8 was unpowered. This had the effect of changing the previously circular shaped contours to a more elliptical shape. In addition the centre of this elliptical region shifted vertically due to the uneven heating effect caused by the unpowered element. As before dispersion is widest without a reflector, and the heat flux becomes more confined with 20mm and again with 50mm reflectors. Maximum heat fluxes for the non reflector, 20mm and 50mm cases are 0.79 W/cm^2, 0.87 W/cm^2 and 1.07 W/cm^2 respectively.

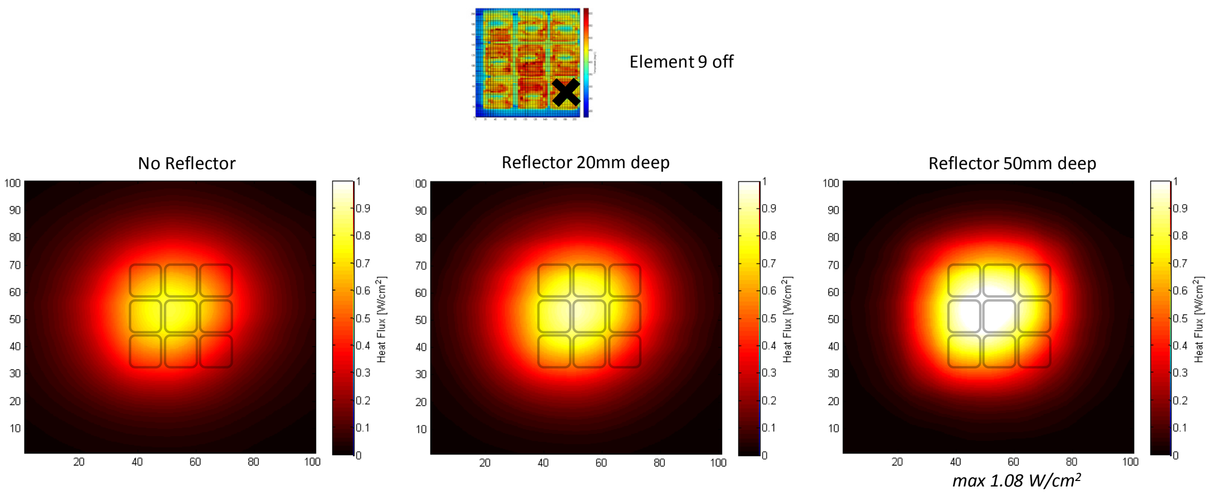

Figure 6: 2D Heat flux at 100mm, element 9 powered off (1200W)

In the final tests seen in Figure 6, a corner element (no. 9) was powered off. The 2D heat flux profiles show a weak area in the bottom right hand corner of the array directly corresponding to the location of the unpowered element. As in the previous cases the dispersion is much decreased by use of the 20mm reflector, and more so with the longer 50mm reflector. Peak heat fluxes were 0.80 W/cm^2, 0.92 W/cm^2, 1.07 W/cm^2 respectively. These were offset away from the unpowered element.

Summary

An array comprising 9 QFE 150W elements arranged in a 3 x 3 pattern was tested with and without surrounding reflectors. In addition various single elements were powered off to study the heat flux profiles. Using the longest reflector minimises dispersion of the emitted radiation and also results in a more confined heat flux spread with higher peak values. In the case of an element being powered off, this results in a general weakening of the radiative heat flux output in the vicinity of the unpowered element. Despite an element being powered off, this will continue to be affected by the surrounding elements and continue to act as an emitter to some degree.

Future investigations could investigate….

- a temperature scan of the array with single elements unpowered
- Temperature and heat flux scans of the array after the complete removal of an element as opposed to just powering it off.