On-Line Motor PD Test at Sasol Synfuels (Pty) Ltd, Secunda, South Africa. 16th September 2002

To Compare the Relative Effectiveness of 500pF vs 80pF PD Couplers

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The following is the results of tests comparing 500pF and 80pF PD Couplers on a working 6.6kV motor on a carbonate pump in a CO_2 separation plant (used in converting coal to petrochemicals). The Motor was connected by shielded (armoured) HV cable >100m long that provided attenuation of external noise which could appear as PD signal from the motor. The test was carried out to demonstrate the proposal that higher value PD couplers have beneficially enhanced sensitivity on lower voltage motors.

A suitable 1.5MW motor was made available, and Sasol technicians made available to make connections. A temporary coupler box was attached and readings taken for 80 and 500pF, both with the existing surge arrestor (Zorc) and without.

Motor: ABB model 75M1090, 1995
6.6kV, 1500kW, 2982rpm,
Eex-n, Class1, Division2.
Insulation "Micadur Compact"
Cold start @ 20C, 90% load.
Max winding temp 70C.

Site: Carbonate Pump no 22PC101C

Couplers: CEF 80/18/5, ser nos 8007, 8009, 8012
CE 500/8/3, ser nos 10649-01-06-0034,
10649-01-02-0105, 10649-01-09-0034,
Analyser: PDA Premium ser no 851, software V1.1.0.0

The PD Couplers were pre-mounted in a temporary Box and connected by HV tails to the terminal box. Sasol were happy to operate with the terminal box open as long as all staff kept clear.

The PD signals were terminated in two temporary 3 way Termination Boxes using 1Kohm termination and 90V arrestors. By only connecting the 50ohm analyser input to the 80 or 500pF couplers in turn, there was no problem of one set of couplers absorbing PD from the other.

The PD signals were measured with the motor both in normal fully loaded operation. It was not possible to operate with low load, as the attached pump would then be in danger of cavitating.

The couplers were connected according to the phase convention: U=A, V=B, W=C (left-right in picture).

The PD test results were taken using Analyser gains of 2 (normal), 4 and 6.25 (max), giving full-scale readings of 800mV, 400mV and 256mV respectively.

All couplers were measured at all three above gains with normal connection. The tests were then repeated with the "Zorc" Surge Suppressor disconnected, in order to determine if this either absorbed PD or was a significant source. The results of all the tests were tabulated for NQN and Qmax and the resultant changes are shown below in a condensed form that allows easy comparison.

Increase 500v80pF	Analyser Gain	NQN+	NQN-	Qmax+	Qmax-
All Phases averaged	2 (800mV)	195%	159%	350%	300%
	4 (400mV)	186%	149%	143%	220%
	6.25 (256mV)	140%	106%	113%	82%
Overall		156%		201%	
No-Zorc Increase	80pF	12%	8%	0%	28%
	500pF	32%	-2%	13%	22%
	Overall	19%			

The results were laid out on a spreadsheet, which is appended.

In considering the results, it should be noted that the machine was started cold (~20C) and run intermittently for 2 hours. During this time it reached 53C, vs full operating temp of ~70C. Thus the PD results would have been affected to some degree by this gradual change of machine parameter.

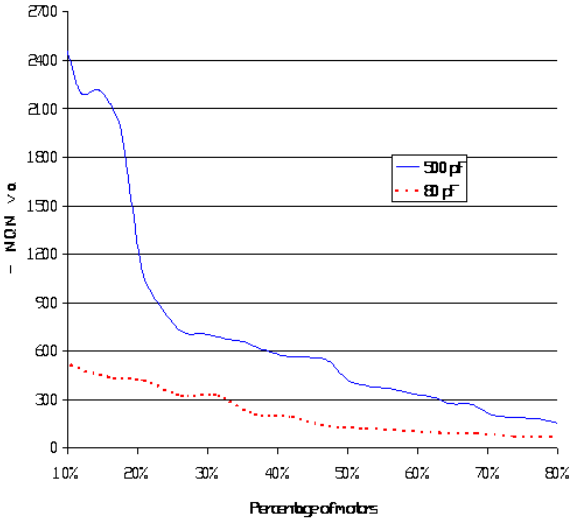
The conclusions that can be drawn from this test are:

1. The amount of PD seen from the 80pF couplers is very low at normal analyser gain (2), and only at higher/highest gains (4 - 6.25) can any significant PD be seen. However using 500pF couplers, significant amounts of PD can be seen at all normal gains.

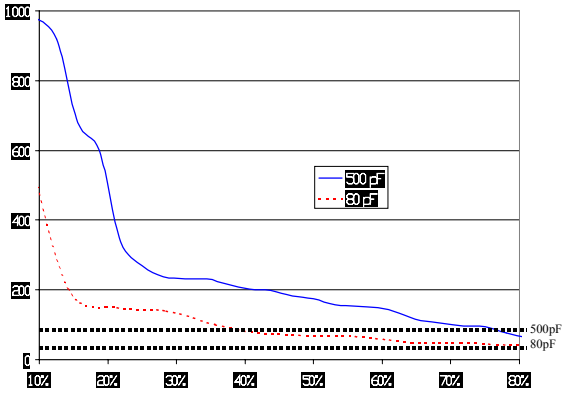
2. The PD signal increase (at gains 2 to 6.25) from 80pF to 500pF couplers was:

   Average Qmax increase 201%
   Average NQN increase 156%

   This is higher than the database average increase of 80-100%. However it must be stressed that the database does not contain identical, side-by-side comparisons such as this. The range of -NQN numbers for 80pF vs 500pF (shown right) is from under 100 to up to 2400, so this variation compared to the median increase is not unreasonable for a single statistical sample.



3. The –Qmax levels were compared to the Adwel database for machines with both 80pF and 500pF couplers as right, and as can be seen this indicates that this machine is in the lower 20-25% quartile for test data. This of course does not warrant that the machine is not at any risk, but does indicate that urgent attention is not warranted. As always, the best data to use for decisions is based on trending a series of tests.



4. There was clear evidence of higher PD activity in V phase on this machine shown by the 500pF couplers, that was not visible on the 80pF couplers (at any gain). A separate rise such as this is usually indicative of activity within a particular PD site within the machine. In this case, considering that it was not visible with the 80pF couplers, indicates that the hf components had been particularly attenuated, thus must be quite deep within the machine winding. The 500pF couplers thus give the ability to trend this activity whilst still at an early stage.

   The phase distribution is also shown below for phase V, gain 4, comparing the two couplers. This shows that the extra higher amplitude PD is generally in the correct timing for deeper phase-earth activity.

5. There was an overall 13% (NQN) and 16% (Qmax) rise in PD on the 80 and 500pF couplers between the Zorc connected and the Zorc disconnected. The reason would naturally be that the Zorc and its wiring has a slight dampening effect on the system. This is small in comparison to the natural variation in PD in a machine. In addition, the tests were not done exactly simultaneously, so some small system/machine variation is possible between tests. It also indicates that this Zorc is not a source of PD.

From this we conclude that the proposal that 500pF couplers are preferable for machines such as this is demonstrated. They allow trending of PD signatures from an earlier stage, when the PD levels are quite low, and also from sites that are deep within the machine, whose PD signals are particularly attenuated by the more capacitive windings of lower voltage machines.

David Bertenshaw
Director, UK Operations

Test at Sasol Secunda, Motor 22PC101C

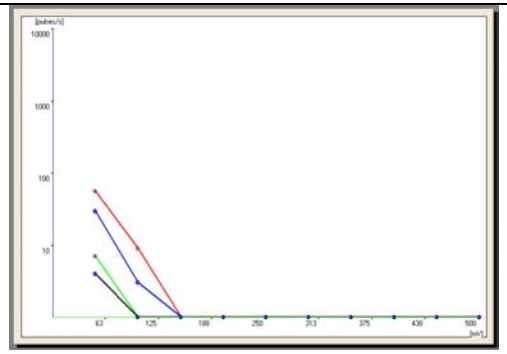
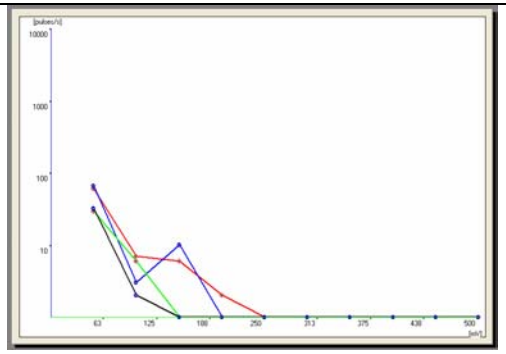
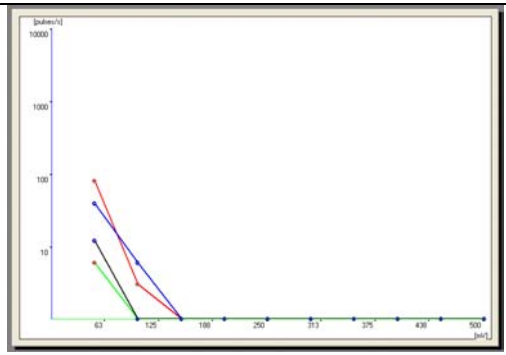
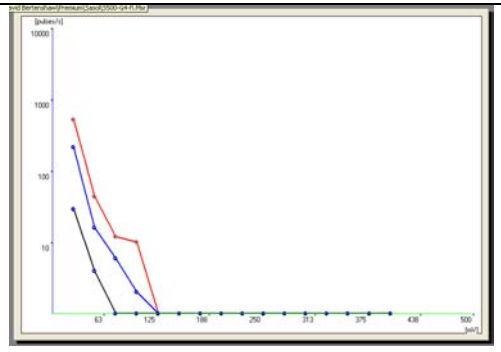
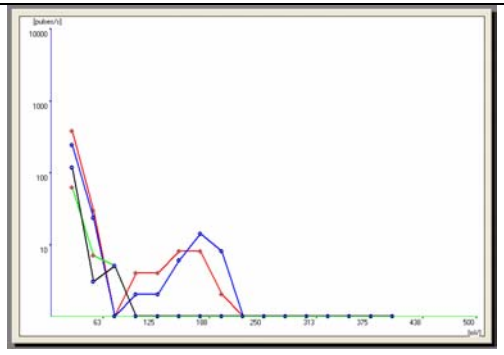
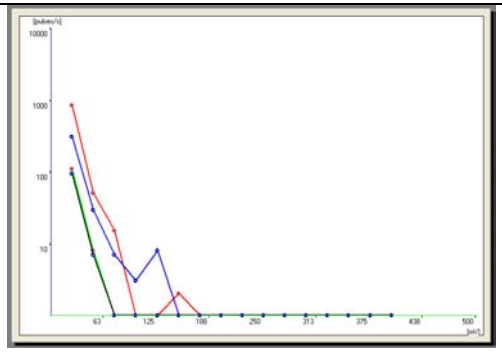
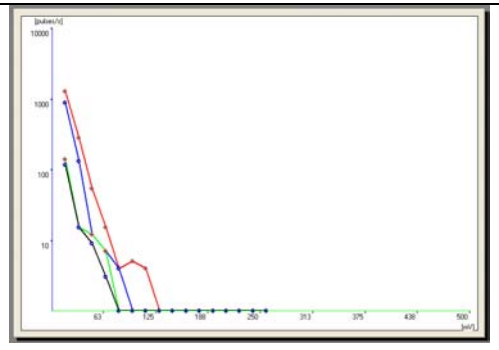
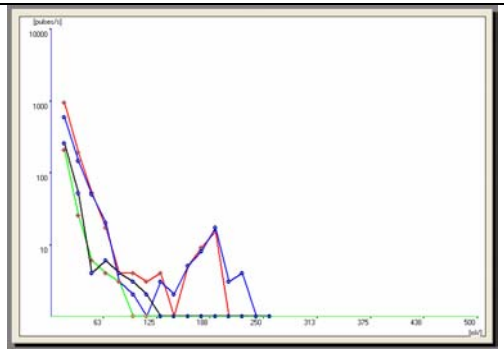
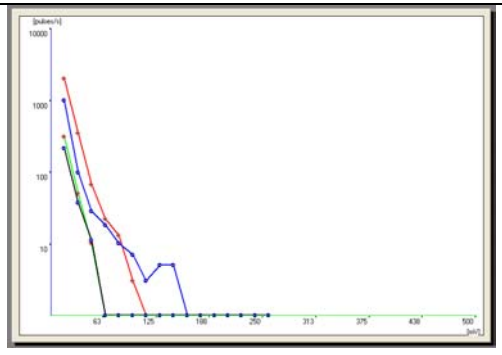
				Phase U				Phase V				Phase W			
	Capacitance	**Gain**	**Max**	**NQN+**	**NQN-**	**Qmax+**	**Qmax-**	**NQN+**	**NQN-**	**Qmax+**	**Qmax-**	**NQN+**	**NQN-**	**Qmax+**	**Qmax-**
Zorc	80pF	2	800	21	15	0	0	75	53	50	50	19	27	0	50
Zorc	80pF	4	400	33	33	25	25	61	55	25	25	48	46	25	25
Zorc	80pF	6.25	256	67	58	48	32	71	91	32	32	63	60	48	48
Zorc	500pF	2	800	91	60	50	50	141	119	50	150	71	79	50	50
Zorc	500pF	4	400	127	86	100	50	151	149	50	175	116	123	75	50
Zorc	500pF	6.25	256	78	102	32	48	189	192	192	192	143	158	80	80
No Zorc	80pF	2	800	21	17	0	0	69	63	50	50	24	24	0	0
No Zorc	80pF	4	400	51	44	25	25	58	58	50	0	39	29	25	25
No Zorc	80pF	6.25	256	63	53	48	48	62	76	32	64	56	65	48	48
No Zorc	500pF	2	800	92	39	50	50	179	102	200	200	102	117	50	100
No Zorc	500pF	4	400	135	86	75	50	157	93	50	25	142	123	75	50
No Zorc	500pF	6.25	256	165	118	80	80	175	138	80	32	165	122	80	64

All Phases Averaged

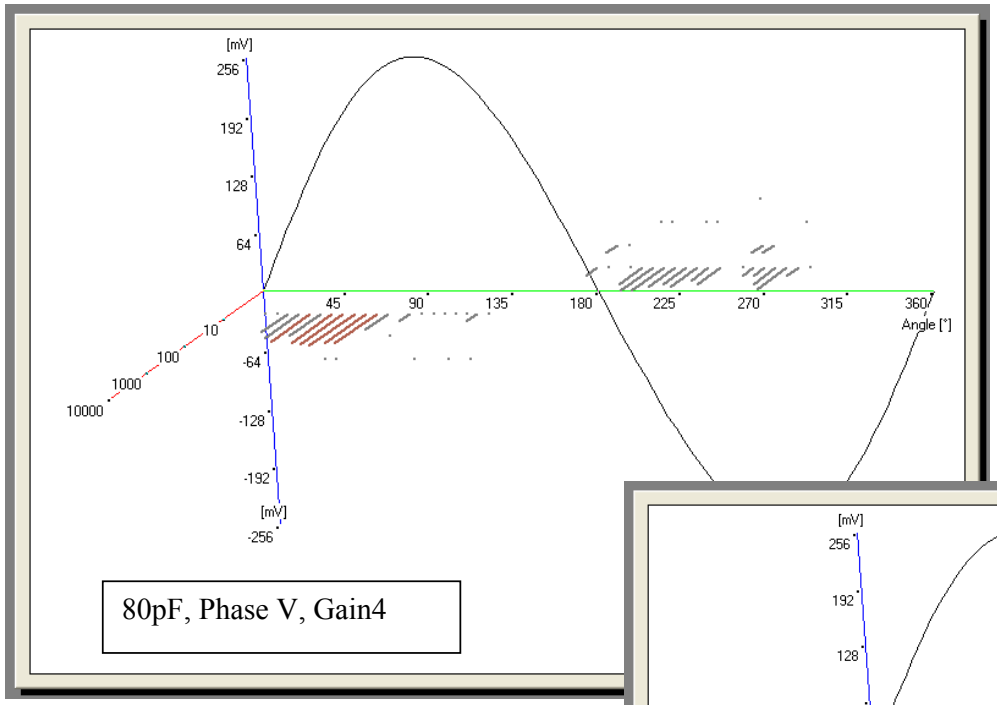
80pF ave	2		38.167	33.167	16.667	25
	4		48.333	44.167	29.167	20.833
	6.25		63.667	67.167	42.667	45.333
	Ave		50.056	48.167	29.5	30.389
500pF ave	2		112.67	86	75	100
	4		138	110	70.833	66.667
	6.25		152.5	138.33	90.667	82.667
	Ave		134.39	111.44	78.833	83.111
500pF vs 80pF Gain	2		195%	159%	350%	300%
	4		186%	149%	143%	220%
	6.25		140%	106%	113%	82%
Overall Gain			156%		201%	
Zorc 80pF			40.333	35.333	24.333	19
Zorc 500pF			98.667	82.667	60.667	49.333
No Zorc 80pF			45	38	24.333	24.333
No Zorc 500pF			130.67	81	68.333	60
No Zorc Gain 80pF			0.1157	0.0755	0	0.2807
No Zorc Gain 500pF			0.3243	-0.02	0.1264	0.2162

No Zorc Gain overall			19%

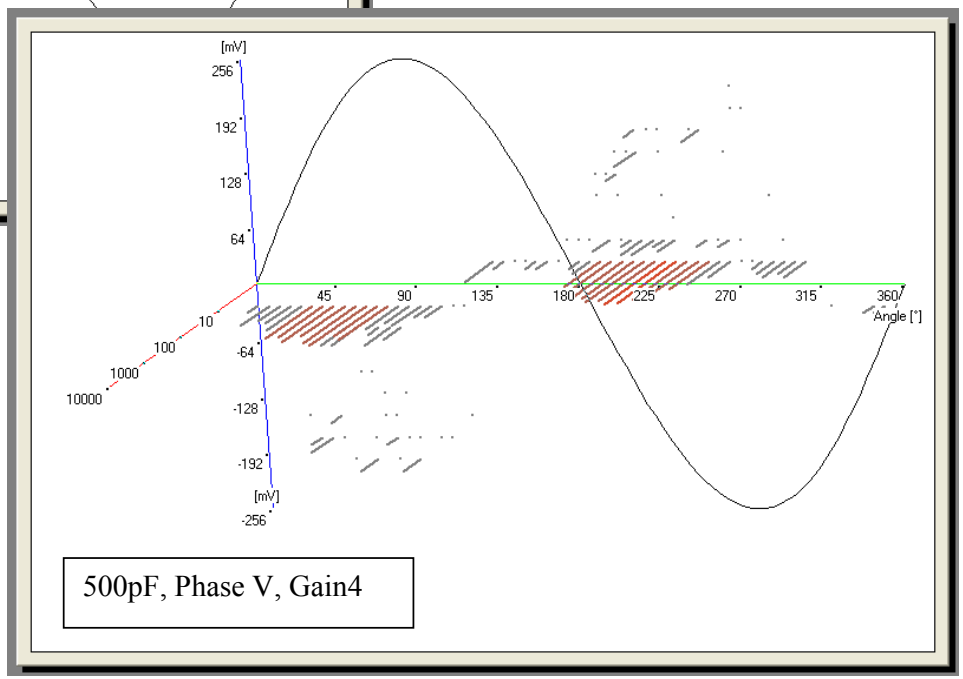
Test Results: 500pF vs 80pF PD (Red-Blue = 500pF, Green-Black = 80pF)

Gain	Phase U = A	Phase V = B	Phase W = C
2			
4			
6.25			

Test Results: PD distribution on Phase V

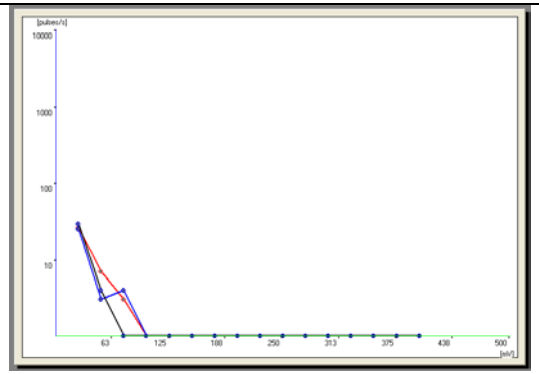
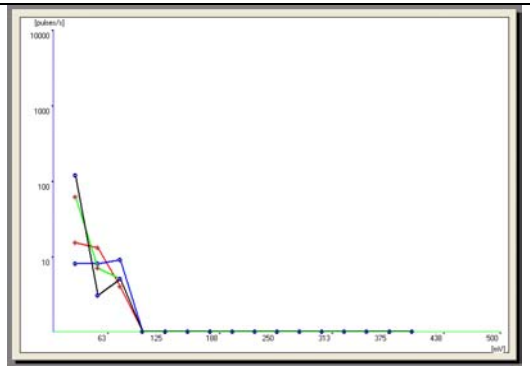
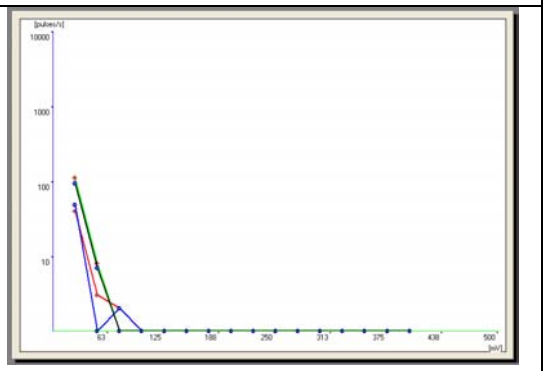


80pF, Phase V, Gain4



500pF, Phase V, Gain4

Test Results: With/without Zorc (Red-Blue = No Zorc, Green-Black = with Zorc)

Gain 4	Phase U = A	Phase V = B	Phase W = C
80pF			
500pF