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Re-Chill

Case Study

Lofprop

50 George Street, London

Secondary ReChill® upgrade

to Climaveneta Chillers

R513A & Inverter Upgrade project

Following the continued success of various Inverter technology applications to new and existing chiller projects, ThermOzone developed a new technique to offer a substantial improvement to prior ReChill® projects, where first undertaken prior to the advent of inverter technology.

The site owners, Lofprop, via their Consultants, Humphrey Clarke Consultants Ltd, were very keen to make all efforts to achieve environmental improvements, and are particularly pleased with the achieved results at this prestigious Mayfair site.

This provides a substantial opportunity to further upgrade chillers already subject to our unique ReChill® techniques several years ago and takes into account not only of another substantial reduction in typical operating energy consumption, but also allows onward service of this equipment as the use of HFC refrigerants reduces as part of the EU wide HFC phase down.

50 George Street is a high status suite of offices in the Mayfair district of London. The air-conditioning provision for the site is provided by two Climaveneta water chillers situated in a deep basement plant room, using ducted air from street level for the necessary condenser cooling and cooling heat rejection. In 2011 ThermOzone undertook one of our then pioneering projects to retrofit the chillers - conversion from piston to screw compressors; removal or HCFC refrigerant R22; new controls. Since then the chillers have proven hardy and robust and reduced their energy demand then ~35%. However, the mode of ventilation at this site has always been a challenge to meet the increasing cooling demands of the site served.

However, it became obvious we could achieve a significant improvement by applying the more recently developed Inverter Drive techniques. Also use of an inverter allows us to increase the operating frequency and with it compressor speed and displacement. Whereas there was no requirement for increased capacity, this did allow us to consider R513A instead of the HFC R407C which had been selected in 2011 to replace the R22 then in use.

R513A offers several advantages and one significant draw back …

It is ~8 - 10% more energy efficient at all operating loads than R407C

It is a lower pressure gas reducing stress on the ageing 1991 original system vessels

Although it is an HFC blend, it has a far lower GWP (Global Warming Potential), and unlike any R22 characteristic gases - R422D; R407C; R438A; etc. Its operating characteristic is near identical to R134a, but with less than half the GWP factor R407C GWP CO_2 Tonnes /kg

R407C	GWP Rating	1,774	CO_2 Tonnes / kg
R134a	GWP Rating	1,430	CO_2 Tonnes / kg
R513A	GWP Rating	630	CO_2 Tonnes / kg

R513A offers a lower specific energy transfer effect. This means a higher volume of refrigerant has to be compressed per unit of cooling. Whereas it does this more efficiently, a larger or higher output compressor is required.

The last factor is provided for by use of the Variable Frequency (Speed) Drive Inverter, and the ability to overspeed to regain the required capacity.

However on this specific site the considerably lower operating pressures of using R513A allowed a far better potential resiliency to deal with the difficult ventilation conditions imposed by the nature of the site as far as the cooling air flow is concerned.

The concept was explained to the principal consultants, Humphrey Clarke Consultants, along with energy predictions and a cost analysis showing potential payback.

As an aside the upgrade re-design was predicted and now shown to also provide an effective payback and ongoing increased reliability and efficiency. The project also required to be cost effective from a capital outlay perspective.

Hence the brief we offered was to assign the previously installed screw compressors with inverter drives, a modification and update to the controls then removal of the R407C in favour of R513A. Associated longer term service works are also being undertaken to ensure ongoing longevity of the plant.

Screw Compressors & Load Control by Variable Frequency Drive Inverters

Re-Chill® has proven modern chiller efficiency can be achieved on most older chiller frames using robust screw compressors and modern controls. However, screw compressors, albeit far more efficient on these applications than piston compressors, themselves have a load efficiency weakness, whereby at partial load the internal load control ‘Slide valve’ reduces energy efficiency progressively below 100% load (displacement volume), with efficiency falling rapidly below 60% slide valve / swept volume at low external load. So effective seasonal load control to satisfy modern demands for an effective SEER / ESEER (efficiency rating) is a crucial area where innovation is very necessary.

New manufacturers have already shown inverter technology can provide variable speed control as an effective mode of compressor motor control, but this is on fully designed from scratch equipment. The Re-Chill® challenge was to apply this to an elderly chiller and achieve the same effective gains …

- ➢ Smoother start / reduced in rush current & power spikes – starts on ~7 amps

- Effective VFD speed control provides variable load from 60 - 140% compressor standard speed of 50 hz (30 - 70 hz).
- Start / Stop cycles drastically reduced
- Therefore a smaller compressor is selected, providing both cost and load turn down benefits, OR the same capacity can be achieved using a more efficient refrigerant
- Duty for duty the turn down ratio is ~ 40% system load, or 20% chiller load
- Reduced rotor tip blow by at lower speeds further improves volumetric efficiency
- COP / EER > 5.7 at low load operation and > 4 at full load

Proven energy savings of screw compressors replacing piston compressors provides an energy saving closely linked to the lesser pumping efficiency due to cylinder & valve losses of the piston compressor compared with the screw equivalent displacement – e.g. circa 25 – 35%. However, at lower load settings (for most chillers ~ 70% of their annual operating cycle), the screw compressor is not optimised, with the slide valve modulating the load well below its optimum efficiency position (100% loaded).

With VFD Inverter control the slide valve is moved to and held at full load position, optimising the screw compressor at its most efficient. By simply slowing it to match the chilled water cooling demand (the load), the specific efficiency increases, because with lower internal gas flow-rates, internal pumping losses are reduced, with less blow-by of compressed gas across the screw rotor tips. Maintaining the oil lip sealing is simpler as the slower motion is not dragging the oil as much as at higher speeds, although the minimum speed is limited by the requirement for sufficient oil flow to lubricate and seal the screw mechanism and bearings.

Preliminary measurements indicate the inverter control improved part load operating efficiency by as much as a further 35% at low load, and overall it is anticipated the running energy saving will be above 50% all round compared with the original piston compressors. A considerable benefit is the very low start current from the ‘Soft Starter’ feature of the inverter.

Associated works

The upgrade to inverter screws requires dedicated load control technology, achieved from the Magnum Controller, which fully supports Variable Frequency Drive Inverter load speed control. The Magnum also provides ancillary chiller control functions – Electronic expansion valve control; system rotation and comprehensive system fault monitoring.

Follow up

ThermOzone undertake the support PPM at competitive rates. As part of this we have also undertaken pre and post project energy checks using our unique M2M technique ‘RODEM’ whereby we can remotely access the chillers through the Internet to not only monitor but also to adjust for seasonal efficiency optimisation and continuous fine tuning. Our predictions and follow up achievements have used this data to formulate the data presented.

Reviewed for Carbon Trust re-application February 2019

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Carbon Trust Accreditation Criterion

Old System / Equipment	ReChill Climaveneta WRAT1202 212kW Chillers 1991 Previously ReChilled in 2011 This project to both chillers (2 off) on the site Dual system with Hanbell RC2-140B screw compressors	
Design rationale	Energy efficiency gains with peripheral benefits of using R513A. As demonstrated upon prior pioneering projects at the National Maritime Museum, Lazard Bank, and other sites where Inverters have been successfully applied.	
Details of new equipment	ReChill secondary upgrade comprising: VFD Inverter drives for compressors; R513A refrigerant; update to chiller controls; inclusion of RODEM remote monitoring.	
Completion date	Late May 2018	
Project cost	Contract price to Clients £42,532 exc VAT	
Net project cost	£42,532 exc VAT	
Offset inevitable works	Estimate of 50% over 5 years	£21,266
Annual savings- Expected	Based upon a Consumption	of £23,000
	Energy savings 34% = £7,820	Net saving per annum
Payback period	Predicted ~2.7 years	Achieving ~ 2.7 years
	(based upon variables shown in payback report)	

Client details	Humphrey Clarke Consultants Representing Lofprop (the property owners and managing agents) Mo Dhachaidh, Beauly IV4 7JS Tel 07875 004795 Email hc@humphreyclarke.com

50 George Street

Site electricity Meter 29.9.16 456351

Chiller 1 Energy usage **Data recorded 29.9.16 @ 13.59 to 20.10.16 @14.34** 26.10.16 464768

~ usage for period 6613

Direct power assessment with data logger

NB Chiller 1 runs in parallel with chiller 2, so overall usage will be double that reported here

	Energy Data Log	5 Minute Intervals			kWH for period	Days	kWH / Day	~ Run hours	**Ambient Temperature log**	5 Minute Intervals
					6611.3	22	300.5	225	19.9 °C	Average for period

kWH / Run hour

TinyTag Energy Logger serial >> 715884 **29.4** Temp logger serial > > 716423

Type TGP-4017

Data line	Date / Time	Average kW Phase L1	Average kW Phase L2	Average kW Phase L3	Av Total Power	Line Volts	kWH per 5 mins	Data line		33 Gracechurch
1	29/09/2016 12:13:59	15.509 kW	15.040 kW	16.536 kW	47.085 kW	0	3.9	1	29/09/2016 12:17	22.243 °C
2	29/09/2016 12:18:59	14.637 kW	14.444 kW	15.799 kW	44.884 kW	0	3.7	2	29/09/2016 12:22	22.526 °C
3	29/09/2016 12:23:59	14.932 kW	14.738 kW	16.101 kW	45.773 kW	0	3.8	3	29/09/2016 12:27	22.497 °C
4	29/09/2016 12:28:59	14.183 kW	14.014 kW	15.362 kW	43.561 kW	0	3.6	4	29/09/2016 12:32	22.578 °C
5	29/09/2016 12:33:59	7.170 kW	7.687 kW	8.503 kW	23.363 kW	0	1.9	5	29/09/2016 12:37	22.484 °C
6	29/09/2016 12:38:59	7.501 kW	8.052 kW	8.820 kW	24.375 kW	0	2.0	6	29/09/2016 12:42	22.574 °C
7	29/09/2016 12:43:59	9.820 kW	10.127 kW	11.095 kW	31.042 kW	0	2.6	7	29/09/2016 12:47	22.646 °C
	Plus 6068 lines of data hidden									
6075	20/10/2016 14:24:28	15.519 kW	15.543 kW	16.635 kW	47.699 kW	0	4.0	6075	20/10/2016 14:27	17.567 °C
6076	20/10/2016 14:29:28	13.642 kW	13.806 kW	14.772 kW	42.222 kW	0	3.5	6076	20/10/2016 14:32	17.863 °C
6077	20/10/2016 14:34:28	8.245 kW	8.943 kW	9.607 kW	26.798 kW	0	2.2	6077	20/10/2016 14:37	17.995 °C
							6611.3			19.859 °C
						kWH for period			Average temperature for period	

App B Summary of energy savings predictions pre project

50 George St			**Efficiency Assessment & Comparison with Inverter drive with R134a**						
	Date			Input kW	System operating conditions	Cooling capacity kW	Compressor load	Estimated capacity	EER (Cooling / Power in)
Operating data from logging session	29 September 2016 to 20 October 2016			29.4	@ +2 SST & +40 SCT	91.1	-	-	3.1
	Hanbell RC2-140B	2 off	R407C @ 50 hz & 38% partial slide valve load						
Inverter estimate	Hanbell RC2-140B	2 off	R134a @ 30 hz	19.4	@ +2 SST & +40 SCT	91.1			4.7
	This is based upon a compressor from the Hanbell range using Hanbell Selection software						This is the equivalent Full Load EER of the Hanbell data model used in this example		
Energy Saving from Inverter	This is a simple calculation of operating EER	from	3.1	to	4.7	**Energy saving estimate achieved by Inverter at equivalent load**			**34%**
	NB Fan efficiencies ignored for this comparision								
	Actual Energy improvements may vary in practice								

50 George St - Analysis Of RODEM report energy snapshots Post Project

	Refrigerant	Ambient	Compressors running	Line Amps	Power CST	kW Input	Cool Duty CST	Cooling duty	COP / EER
21/11/18	R513A	20.2	1	37.4	0.72	26.9	158.0	158	5.8
19/10/18	R513A	17.4	1	39.9	0.72	28.7	158.0	173.8	6.0
17/9/18	R513A	25.8	2	101.3	0.72	72.9	158.0	284.4	3.9
26/8/18	R513A	24.1	2	75.0	0.72	54.0	158.0	221.2	4.1
24/7/18	R513A	34.1	4	191.6	0.72	137.9	158.0	410.8	2.9
29/6/18	R513A	28.7	3	156.3	0.72	112.5	158.0	363.4	3.2
5/6/18	R513A	17.8	1	28.7	0.72	20.6	158.0	126.4	6.1
Averaging period Jun - Nov 2018			**2**	**90.0**		**64.8**		**248.3**	**4.6**
	Change from R407C to R513A with Inverters late May 2018								
14/5/18	R407C	21.6	2	76.5	0.72	55.0	158.0	173.8	2.9
24/4/18	R407C	23.0	2	68.2	0.72	49.1	158.0	158.0	3.2
22/3/18	R407C	17.3	1	34.0	0.72	24.4	158.0	79.0	3.0
16/2/18	R407C	14.1	1	54.9	0.72	39.5	158.0	126.4	3.2
21/1/18	R407C	21.5	1	51.8	0.72	37.2	158.0	126.4	3.3
7/12/17	R407C	16.1	1	31.1	0.72	22.3	158.0	142.2	6.3
22/11/17	R407C	25.5	1	33.1	0.72	23.8	158.0	79.0	3.3
24/10/17	R407C	22.1	1	32.2	0.72	23.1	158.0	78.5	3.4
27/9/17	R407C	22.5	1	44.3	0.72	31.9	158.0	108.5	3.4
22/8/17	R407C	24.8	3	97.7	0.72	70.3	158.0	205.4	2.9
20/7/17	R407C	26.0	3	112.9	0.72	81.2	158.0	252.8	3.1
21/6/17	R407C	35.6	4	204.8	0.72	147.4	158.0	410.8	2.7
Averaging period Jun - Nov 2017			**2**	**87.5**		**62.95**		**189.2**	**3.1**
Averaging period 2018 (from above)	**Energy Saving as an average %**		**31.5%**	**90.0**		**64.8**		**248.3**	**4.6**
Prior Sample Reports									
13/8/16	R407C	26.3	2	73.9	0.72	53.2	158.0	173.8	3.2
4/1/16	R407C	21.5	1	32.8	0.72	23.6	158.0	79	3.3
2/11/15	R407C	18.5	4	209.9	0.72	151.1	158.0	395	2.6
8/10/15	R407C	24.3	2	80.2	0.72	57.7	158.0	205.4	3.2
21/9/15	R407C	27.3	1	36.5	0.72	26.2	158.0	110.6	4.1
13/7/15	R407C	26.3	2	73.9	0.72	53.2	158.0	173.8	3.2
22/6/15	R407C	25.4	3	94.4	0.72	67.9	158.0	142.2	2.0
12/5/15	R407C	24.8	2	89.8	0.72	64.6	158.0	126.4	1.9

ReChill®

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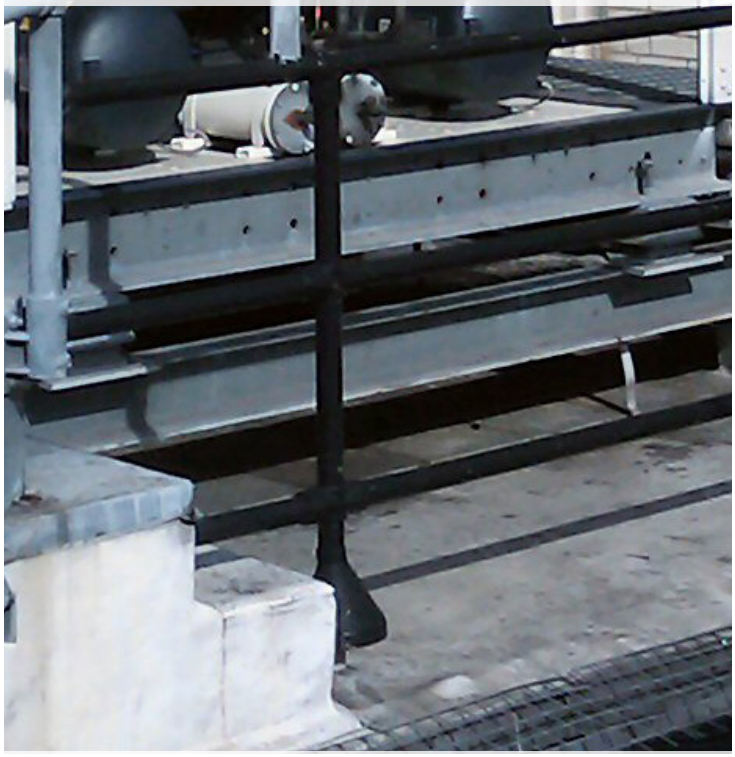
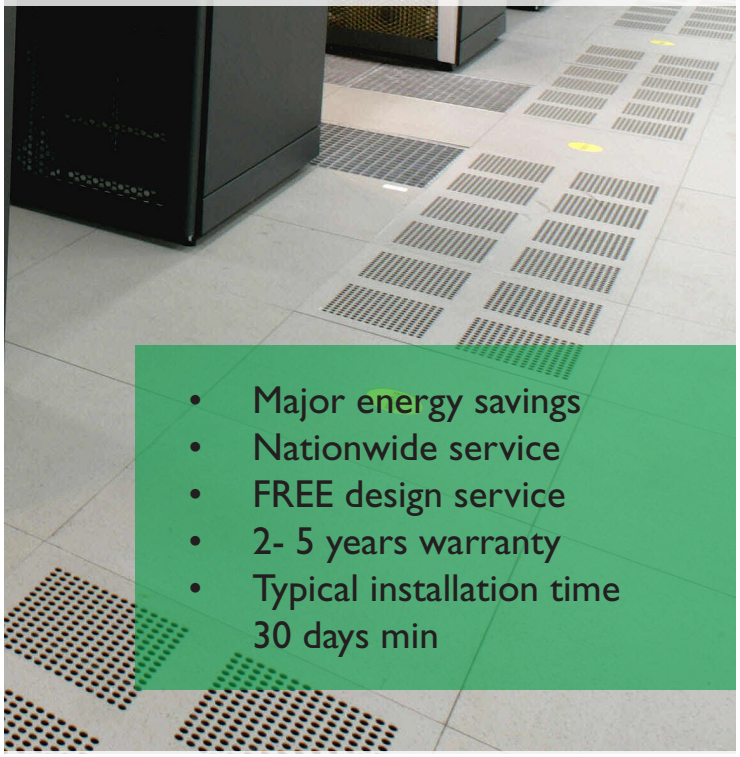
Replacing your existing chiller with new can be logistically difficult and costly, so Re-Chill allows the client an extra option to remanufacture their existing chiller with bespoke equipment and bring the chiller to an energy efficient level all while reducing the disruption to the building and avoiding the additional costing which "new" can bring.





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- Nationwide service
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