Inspection Methodology – Air Conditioning Maintenance Tasks - Identifying Energy Savings

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By

D. Wright and M. Sheldon MacWhirter Limited
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iSERV Project Team

Welsh School of Architecture,
Cardiff University
UK (Project co-ordinator)

K2n Ltd
UK

MacWhirter Ltd
UK

National and Kapodistrian University of Athens
Greece

University of Porto
Portugal

Politecnico di Torino
Italy

Université de Liège
Belgium

Univerza v Ljubljani
Slovenia

University of Pecs
Hungary

Austrian Energy Agency
Austria

REHVA
EU

CIBSE
UK

This document sets out to describe the various maintenance tasks associated with air conditioning systems, the reasons for carrying them out, the typical intervals, what, if anything, is done on a typical maintenance visit and whether further work is normally the responsibility of the contractor or the client (in respect of further costs), whilst highlighting those, which would save energy in cooling mode, and where possible apply a HARMONAC ECO reference number to them. It is not exhaustive or definitive but is intended to of use to both maintenance engineers and energy inspectors alike.

Introduction

- **FACTORS AFFECTING AIR CONDITIONING SYSTEM EFFICIENCY**

The inherent efficiency of the system is affected by the efficiencies of:

- the refrigeration equipment that removes heat,
- the refrigerant fluid chosen, and its charge in the system,
- heat rejection to atmosphere,
- the delivery of cooled air or water to, or other means of absorbing heat from, the treated spaces,
- any associated ventilation air supply and/or extract system.

The operating efficiency of an air conditioning system depends on a number of factors:

- the inherent efficiency of the system,
- its state of maintenance, and
- its effective control.

This document deals with the state of maintenance.

The tasks should only be attempted by a competent person with the appropriate risk assessments in place.

ECO Ref. No.	HARMONAC (Facility Management) Energy Conservation Opportunity	Energy Saving
O1.1	Generate instructions (“user guide”) targeted to the occupants	NLTD
O1.2	Hire or appoint an energy manager	NLTD
O1.3	Train building operators in energy – efficient O&M activities	NLTD
O1.4	Introduce an energy – efficient objective as a clause in each O&M contract	NLTD
O1.5	Introduce benchmarks, metering and tracking as a clause in each O&M contract, with indication of values in graphs and tables	
O1.6	Update documentation on system / building and O&M procedures to maintain continuity and reduce troubleshooting costs	NLTD
O1.7	Check if O&M staff are equipped with state of the art diagnostic tools	
O2.1	Use an energy accounting system to locate savings opportunities and to track and measure the success of energy – efficient strategies	
O2.2	Shut off A/C equipment when not needed	65%
O2.3	Shut off auxiliaries when not required	
O2.4	Maintain proper system control set points	5.55%
O2.5	Adjust internal set point values to external climatic conditions	
O2.6	Implement pre-occupancy cycle	NLTD
O2.7	Sequence heating and cooling	
O2.8	Adopt variable speed control strategy	

ECO Ref. No.	HARMONAC (Facility Management) Energy Conservation Opportunity	Energy Saving
O3.1	Shut Chiller plant off when not required	
O3.2	Sequence operation of multiple units	NLTD
O3.3	Operate chillers or compressors in series or parallel	
O3.4	Track and optimize chillers operation schedule	
O3.5	Maintain proper starting frequency and running time of (reversible) chillers	
O3.6	Improve part load operation control	
O3.7	Maintain proper evaporating and condensing temperatures	4.43%
O3.8	Raise chilled water temperature and suction gas pressure	
O3.9	Lower condensing water temperature and pressures	NLTD
O3.10	Check sensor functioning and placement for (reversible) chillers	NLTD
O3.11	Maintain efficient defrosting (reversible Chiller)	
O3.12	Maintain proper heat source/sink flow rates	8.86%
O3.13	Maintain functioning of (reversible) Chiller expansion device	
O3.14	Check (reversible) Chiller stand-by losses	
O3.15	Maintain full charge of refrigerant	29.70%
O3.16	Clean finned tube evaporator / condenser air side and straighten damaged fins	7.65%
O3.17	Clean condenser tubes periodically (Water Cooled)	
O3.19	Clean and maintain cooling tower circuits and heat exchanger surfaces	
O3.20	Apply indirect free cooling using the existing cooling tower (free chilling)	
O4.1	Consider modifying the supply air temperature (all–air and air–and–water systems)	
O4.2	Perform night time over ventilation	
O4.3	Shut off coil circulators when not required	
O4.4	Replace mixing dampers	
O4.5	Adjust fan belts (AHU, packaged systems)	
O4.6	Eliminate air leaks (AHU, packaged systems)	
O4.7	Increase outdoor air flow rate (direct free cooling)	
O4.8	Adjust/balance ventilation system	
O4.9	Reduce air flow rate to actual needs	10.07%
O4.10	Check maintenance protocol in order to prevent pressure losses	
O4.11	Reduce air leakage in ducts	NLTD
O4.12	Clean fan blades	NLTD
O4.13	Maintain drives	NLTD
O4.14	Clean or replace filters regularly	19.73%
O4.15	Repair/upgrade duct, pipe and tank insulation	NLTD
O4.16	Consider the possibility to increase the water outlet – inlet temperature difference and reduce the flow rate for pumping power reduction	
O4.17	Balance hydronic distribution system	
O4.18	Bleed air from hydronic distribution system	
O4.19	Switch off circulation pumps when not required	
O4.20	Maintain proper water level in expansion tank	
O4.21	Repair water leaks	
O4.22	Reduce water flow rates to actual needs	

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Interval	ECO	Task	Reason		Actions
A/C Split & Small Packaged					
Half Yearly	O1.6	Check O & M records	Including F-gas leak checks and energy Inspections.		Evidence of system problems would be investigated should they be within the remit of the contract, otherwise the client would be advised and costs given to further investigate them.
Half Yearly		Check complaints records	Complaints records give an indication of poor system performance, control or design.		Maintenance operatives may not always be at liberty to enquire about complaints directly from staff. However, it is the duty of the builder manager to carry out a thermal comfort risk assessment which should include the adjoining Employer's Thermal Comfort Check List found in the UK's Health & Safety Executive's Guidelines for Thermal Comfort in the Workplace. Evidence of poor thermal comfort would be investigated should the factor be within the remit of the contract, otherwise – the client would be advised and costs given to further investigate them.
			FACTOR	**DESCRIPTION**	
			Air temperature	Does the air feel warm or hot?	
				Does the temperature in the workplace fluctuate during a normal working day?	
		Check complaints records		Does the temperature in the workplace change a lot during hot or cold seasonal variations?	
			Radiant Temperature	Is there a heat source in the environment?	
			Humidity	Is there any equipment that produces steam?	
				Is the workplace affected by external weather conditions?	
		Check complaints records		Are your employees wearing PPE that is vapour impermeable?	

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Interval	ECO	Task	Reason		Actions
				Do your employees complain that the air is too dry?	
				Do your employees complain that the air is too humid?	
			Air Movement	Is cold or warm air blowing directly into the workspace?	
				Are employees complaining of draught?	
			Metabolic Rate	Is work rate moderate to intensive in warm or hot conditions?	
				Are employees sedentary in cool or cold environments?	
			PPE	Is PPE being worn that protects against harmful toxins, chemicals, asbestos, flames, extreme heat etc?	
				Can your employees make individual alterations to their clothing in response to the thermal environment?	
				Is respiratory protection being worn?	
			What your employees think?	Do your employees think that there is a thermal comfort problem?	

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Interval	ECO	Task	Reason	Actions
Half Yearly		Check for general correct operation	As per 'The use of basic tactile and visual techniques in the inspection of air conditioning systems' http://www.harmonac.info/fileadmin/downloads/papers/Tactile_Approach.pdf	Client would be advised of any faults or problems and costs given to rectify them.
Half Yearly	O3.16, O3.12	Check condenser coil	For every 10K rise in condensing temperature there could be a 1.35% reduction in evaporator capacity and corresponding increase in power consumption. HARMONAC measured increase from Field Trials: 7.65%	Condensers would normally be cleaned under the maintenance contract unless perhaps if it was excessively contaminated and needed a 'heavy duty clean', for instance, for which the client would be given costs. The reason for heavy contamination would be investigated and depending on where the blame lies either the client or the contractor would responsible for the cleaning with the contractor advising of cost if appropriate and advising on a more suitable maintenance regime if necessary. Corroded fins can be treated with coatings to prevent worsening and therefore future increases in energy consumption; treatments such as Blygold, it is claimed, also increase the efficiency by 1-2%, in respect of the increasing the thermal conductivity of the fins.
Half Yearly	O3.16	Check evaporator coil	A dirty evaporator coil would result in reduced system duty without a reduction in motor/compressor running current -the energy consumption would be increased by virtue of the compressor running for longer	Normally cleaned under the maintenance contract at no extra cost unless perhaps if it was excessively contaminated and needed a 'heavy duty clean', for instance, for which the client would be given costs. The reason for heavy contamination would be

Interval	ECO	Task	Reason	Actions
			periods to maintain the conditions. Energy efficiency reductions would be similar to filters.	investigated and depending on where the blame lies either the client or the contractor would responsible for the cleaning with the contractor advising of cost if appropriate and advising on a more suitable maintenance regime if necessary.
Half Yearly	O4.9 O4.12	Check condition/operation of indoor fan	Check that fan impeller is secure, there is no evidence of vibration and the blades are not damaged or contaminated with dirt or mold which would result in low air flow and therefore low evaporating temperatures and the associated reduction of compressor efficiency. Although air flow should maintained to suit actual needs, too low an air flow could adversely affect the efficiency of a DX system. However, HARMONAC showed that where air flows were too high reducing them to actual needs saved on average 10% energy.	Fan would be normally cleaned during the maintenance inspection at no extra cost.
Half Yearly	O4.13	Check bearings of fans and motors.	Stiff or worn condenser fan motors would result in higher running amps and high condensing pressures-see condenser coil above. Stiff or worn evaporator fan motors would result in higher running current and low evaporating pressures/temperatures- see check evaporator coil above.	Client would be given costs to repair or replace fan motors if found to be faulty.
Half Yearly	O2.3	Check crankcase heater	An inoperative or badly fitting compressor crankcase heater would result in liquid refrigerant migrating to the crankcase in low ambient conditions, which would cause high starting currents, stalling completely on start up, low oil pressure due to	Faulty crankcase heater: Client would be advised and given costs of this low cost repair. Electrical isolation/disconnection of a crankcase heater during a

Interval	ECO	Task	Reason	Actions
			foaming or liquid refrigerant to enter the cylinders. May cause eventual mechanical or electrical failure of the motor/compressor. Crankcase heaters left on for long periods during the heating season can consume excessive energy.	prolonged scheduled compressor off period would not be done unless the end user requested it-it should be noted that the restarting of the compressor should not be done without a service engineer in attendance to ensure that the crankcase heater has been energized for a suitable time, to avoid a possible catastrophic mechanical failure of the compressor and/or electrical failure in the case of a motor/compressor.
Half Yearly	O3.15	Check the refrigeration pipe work, brackets for evidence of vibration etc	Evidence (oil staining etc) of leaks could indicate that system has lost refrigerant. Evidence of vibration could indicate a potential leak through pipe fracture etc.	Corroded, loose of missing brackets would be reported along with a cost to remedy. Evidence of vibration would be investigated and any cause that could be remedied by tightening of a component would be eliminated on the maintenance inspection. Other actions like altering of pipe-work, installing shock loops or vibration eliminators would be reported to the end user along with a cost.
Half Yearly	O4.15	Check the condition of pipe-work insulation.	Bare pipe work or even loss of vapour seal could cause high superheat of the suction line through the absorption of sensible and latent heat, and resulting in high motor/compressor and condensing temperatures etc which would cause higher energy input.	The client would be given a cost to repair or replace the insulation.
Half Yearly	O4.6 O3.15	Check the general condition of the indoor unit.		As per 'The use of basic tactile and visual techniques in the inspection of air conditioning systems'

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Interval	ECO	Task	Reason	Actions
			A great deal of information can be found during an initial Sight, Sound And Smell inspection.	http://www.harmonac.info/fileadmin/downloads/papers/Tactile_Approach.pdf Minor defects may be rectified during visit with more profound problems reported and the client given costs.
Half Yearly	O4.6 O3.1 O3.15 O3.16	Check the general condition of the outdoor unit.	A great deal of information can be found during an initial Sight, Sound And Smell inspection.	As per 'The use of basic tactile and visual techniques in the inspection of air conditioning systems' http://www.harmonac.info/fileadmin/downloads/papers/Tactile_Approach.pdf Minor defects may be rectified during visit with more profound problems reported and the client given costs.
Half Yearly	NLTD	Check condition of pcbs, relays and contactors.	High resistance, through arcing or dirt, on the contactor or relay contacts result in higher operating amperages and possible motor/compressor failure.	Client would be given costs to replace contactors/relays etc.
Half Yearly	NLTD	Check electrical terminals for tightness.	Bad connections will cause high operating amperages	Normally rectified under maintenance contract at no cost providing it was a simple repair.
Half Yearly	NLTD	Check electrical cables for damage and overheating.	Cables overheating would indicate high operating amperages and therefore high energy use.	The reason would normally be investigated under the maintenance contract and minor problems like loose connections rectified, but more profound problems would be reported along with cost of repair.
Half Yearly	O4.14	Inspect air filters.	Dirty filters would result in reduced system duty (2 - 4% for every 1K reduction in evaporating temperature) without a reduction compressor	Cleaning filters and changing them, providing replacements were already onsite, would be carried out under the maintenance contract;

Interval	ECO	Task	Reason	Actions
			running current – the increase in energy consumption would be up by virtue of the compressor running longer. HARMONAC average energy saving after cleaning filters: 24.94% Filters with a too low filtration rate could result in dirty cooling coils and fans.	replacements would be charged for as would the labour costs if they were to be changed outside of the scheduled maintenance regime, although this obviously depends on any contractual arrangement. End users would be advised if a more suitable filter inspection regime is required and a cost would be provided.
Half Yearly	O3.10	Check condition and positioning of return air sensor.	Dirty, damaged or inappropriate positioned sensing elements can result in, for instance, loss of conditions in the space and/or excessive operation, which in the latter might result in higher energy usage.	Dirty sensor would be cleaned under the maintenance contract. Re-positioning of a sensor may be carried out under the maintenance contract providing it was a simple procedure otherwise advice and costs would be given to the client
Half Yearly	NLTD	Inspect discharge and return air grilles.	Check for cleanliness and correct air distribution. A dirty or obstructed return air grille would reduce the air flow and adversely affect the refrigeration system efficiency as well the air distribution through reduced velocity. A dirty discharge grille or stains on the wall or ceiling adjacent to it would indicate that the filters are not being cleaned or replaced often enough or that they are not effective.	Would be normally cleaned under the maintenance contract
Half Yearly	NLTD	Check for general correct operation.		As per 'The use of basic tactile and visual techniques in the inspection of air conditioning systems' http://www.harmonac.info/fileadmin/downloads/papers/Tactile_Approach.pdf

Interval	ECO	Task	Reason	Actions
				Minor defects may be rectified during visit with more profound problems reported and the client given costs.
Half Yearly	O3.4 O3.2 O3.1 O2.7 O2.5 O2.4, O2.2 O1.3 O1.1	Check operation and settings of controller	Ensure that appropriate mode is being used, the temperature is set correctly (generally between 19 & 23°C), a suitable fan speed is selected, the time schedule is correct and that each function operates correctly. HARMONAC Field Trials showed that if time schedules were shortened or use based on occupancy in meeting rooms etc there would be an average saving of 97%	If necessary, the user should be advised on the correct use of the controller.
Half Yearly	O3.15	Check for refrigerant leaks	Carry out visual inspection of external surfaces for any evidence of leakage from the system. Leak checking should be carried out as per the requirements of the F-gas and ODS (Ozone Depleting Substances) Regulations, which should be at least the Indirect Leak Detection Method. Refrigerant charge too low would increase compressor running time and eventual loss of capacity, and too high would result in higher run amps. Motor/compressors could eventually fail and need replacing (sustainability ECO). HARMONAC average: 29.7% increase in energy by virtue of the longer compressor running time even though this would have been at a lower energy input.	Evidence of leakage would be followed up by a leak test with electronic leak test and any minor cost repairs rectified, normally under the maintenance contract. In the event of major problems or if the leak could not be found, the client would be advised of the further work (the refrigerant may have to be removed and the system pressurized with oxygen-free nitrogen or dye added, for instance) required, and costs given. F-Gas leaks have to be repaired as soon as possible and ODS leaks have to be repaired within 14 days.

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Interval	ECO	Task	Reason	Actions
Half Yearly	O3.7	Check condenser pressure controls	Condenser fan cycling/speed controllers and dampers, not set correctly could cause over or under condensing. Both conditions would result in poor efficiency, and therefore longer compressor running time, and under condensing would mean higher running currents also. HARMONAC average saving was measured at 4.43%	Would normally be adjusted under the maintenance contract. Costs, including labour, for replacing faulty controllers etc would be given.
Half Yearly	O3.16	Sanitize indoor and outdoor unit coils	Is done primarily to eliminate/prevent smells on indoor units but can be effective in preventing bacterial and fungal growth, where there is a problem, which could cause the coil to block up and reduce the air flow. Although sanitizing can give peace of mind in respect of Legionella.	Only normally carried out if specifically requested by client although many coil cleaning products contain sanitizing agents.
Half Yearly		Check condensate drain	Health & Safety. Condensate drip tray and drain trap should be cleaned (and sanitized if necessary), water flushed through to ensure free flow away and through the drain. Although there would normally be no risk from Legionella it is good practice to ensure that the condensate tray and drain are free from any slime, sludge and scale which could enable the growth of harmful pathogens.	Would be carried out by the contractor under the contract but drain blockages not adjacent to the unit would be reported to the client and costs given to remedy or to allow their own plumber to carry out the work. Biocide tablets would be placed in the drip tray if specifically requested by the client -could be costed as an extra or included in the maintenance contract.
Half Yearly	O1.6	Update O & M and log books.	Essential for the monitoring of energy efficiency and to aid energy inspections and F-Gas compliance.	Not always done by the contractor who might only issue reports, unless specifically contracted to do so.

Interval	ECO	Task	Reason	Actions
Yearly	O1.7 O2.4 O3.5 O3.7 O3.10 O3.13 O3.11 O3.12	Carry out full diagnostics procedure.	Operating temperatures and pressures of the refrigeration system and compressor running currents would be checked and/or it would checked with manufacturer's software monitoring tool & lap top. Operating pressures of small critically charged systems would not normally be checked. The use of datalogging equipment such as Climacheck would not be used unless a specific requirement of the contract.	Minor problems, like valve adjustments, would be rectified under the maintenance contract but those, like loss of refrigerant or motor/compressor not pumping 100%, for instance, would, be subject to a cost for repair.
			AHUs	
Half Yearly	O4.14	Check unit filter	Dirty filters would result in reduced system duty (2 - 4% for every 1K reduction in evaporating temperature) without a reduction compressor running current – the increase in energy consumption would be up by virtue of the compressor running longer. HARMONAC average energy saving after cleaning filters: 24.94% Filters with a too low filtration rate could result in dirty cooling coils and fans. Filters with a too high filtration rate could result in higher pressure drops on duct work resulting in higher fan running current and reduced air flow causing low refrigeration efficiency.	Normally cleaned or replaced if replacements are on site at time of visit under the maintenance contract at no extra cost-although on a minor visit the client may only be advised of the filters being dirty. The client would normally pay for new filters, and for the fitting of them outside of the maintenance schedule, although they would be encouraged to maintain a supply on site.
Half Yearly	O2.4 O2.3		Humidistats should be set correctly to avoid using the cooling system and re-heaters to dehumidify unnecessarily, where there is a de-	Humidifiers would be checked for scaling and cleaned if necessary or appropriate if it affect its ability to produce steam.

Interval	ECO	Task	Reason	Actions
		Check operation of humidifier/humidity controls Check operation of humidifier/humidity controls cont.	humidification function, or operating the humidifier unnecessarily which would add to the internal heat load gains- both of which would increase the energy use.	Many computer rooms with close control systems have been re-designated as COMMS or server rooms which may not need such precise conditions as the older computer rooms (21^0C +/- 1^0C and 50%RH +/- 5%). It is more likely to be 22^0C +/- 2^0C and 35% to 80% RH. There may also be a large reduction of the internal gains from the computer equipment resulting in high humidity levels causing continuous de-humidification. Both the humidification and the de-humidification modes could be disabled to reduce running costs and improve the temperature control humidification. In these circumstances. Advice should be given to the client and their approval sought before carrying out any changes.
Half Yearly		Check condensate drain.	Health & Safety Condensate drip tray and drain trap would be cleaned (and sanitized if necessary), water flushed through to ensure free flow away and through the drain. Although there would normally be no risk from Legionella it is good practice to ensure that the condensate tray and drain are free from any slime, sludge and scale which could enable the growth of harmful pathogens.	Drain blockages not adjacent to the unit would be reported to the client and costs given to remedy or to allow their plumber to carry out the work. Biocide tablets would be placed in the drip tray if specifically requested by the client -could be costed as an extra or included in the maintenance contract.
Half Yearly	O4.5	Check condition and correct operation of fan,	Check that fan impeller is secure, there is no evidence of vibration	Fan would be normally cleaned during the

Interval	ECO	Task	Reason	Actions
	O4.12 O4.13	fan motor and drive parts	and the blades are not damaged, contaminated with dirt or mold which would result in low air flow and therefore low evaporating temperatures and the associated reduction of compressor efficiency. Drive belts and pulleys would be checked for wear and/or tightness - wear of the pulley vee can reduce the diameter of the pulley causing the fan to rotate faster (or vice versa) thus increasing the air flow and the motor running current. Although air flow should maintained to suit actual needs, too low an air flow could adversely affect the efficiency of a DX system. However, HARMONAC showed that where air flows were too high reducing them to actual needs saved on average 10% energy.	maintenance inspection at no extra cost.
Half Yearly		Check operation of controls and safety switches.	Essential for maintaining integrity and operation of system	Normally carried out under the maintenance contract
Half Yearly	O3.16	Inspect DX cooling (evaporator) coil	A dirty DX evaporator coil would result in reduced system duty - the loss of efficiency would be similar to that of a dirty filter.	A dirty coil would usually be the result of an inadequate filter cleaning/changing regime or through untreated air ingress. Normally cleaned under the maintenance contract at no extra cost unless heavily contaminated when costs may be given to 'heavy duty' or steam clean. The reason for heavy contamination would be investigated and depending on where the blame lies either the client or the contractor would responsible

Interval	ECO	Task	Reason	Actions
				for the cleaning with the contractor advising of cost if appropriate.
Half Yearly		Inspect chilled water and LPHW coils	A dirty chilled water cooling coil would result in loss of conditions in the space with a probable reduction in energy usage.	A dirty coil would usually be the result of an inadequate filter cleaning / changing regime or through untreated air ingress. It would normally cleaned under the maintenance contract at no extra cost unless heavily contaminated when costs may be given to 'heavy duty' or steam clean. The reason for heavy contamination would be investigated and depending on where the blame lies either the client or the contractor would responsible for the cleaning with the contractor advising of cost if appropriate.
Half Yearly		Check all intake and exhaust grilles	A dirty return air grille would reduce the air flow and adversely affect the refrigeration system efficiency as well the air distribution through reduced velocity. .	Would normally be cleaned under the maintenance agreement.
Half Yearly		Clean all unit mounted air diffusers, plenum grilles etc.	Check for cleanliness and correct air distribution. A dirty discharge grille or stains the wall or ceiling adjacent to it would indicate that the filters are not being cleaned or replaced often enough or that they are not effective.	Would normally be cleaned under the maintenance agreement.
Half Yearly		Check electrical terminals for tightness.	Bad connections will cause high running currents.	Normally rectified under maintenance contract at no cost providing it was a simple repair.

Interval	ECO	Task	Reason	Actions
Half Yearly	O3.10	Check all direct sensing temperature bulbs or probes and check they correctly located and undamaged.	Dirty, damaged or inappropriate positioning sensing elements can result in, for instance, loss of conditions in the space and/or excessive operation, which in the latter might result in higher energy usage.	Dirty sensor would be cleaned under the maintenance contract.
Yearly	O4.6	Examine AHU for corrosion, deterioration & cleanliness including the casing and access panels internally & externally	Loss of pressure will reduce the air flow which besides affecting the air distribution would reduce the efficiency of the refrigeration system. Alternatively, the ingress of air from unconditioned spaces could cause inefficient operation.	Normally cleaned on a maintenance inspection unless heavily contaminated when costs would be given.
Yearly	O4.6	Check all canvas ducts and duct connections.	Loss of pressure will reduce the air flow which besides affecting the air distribution would reduce the efficiency of the refrigeration system. Alternatively, the ingress of air from unconditioned spaces could cause inefficient operation.	Condition would be reported to client with repair costs from duct work specialist.

Interval	ECO	Task	Reason	Actions
Air Ducting				
Yearly	NLTD	Check all intake, return air and exhaust grilles for obstruction.	Dirty/blocked intake grilles can have the same effect as a dirty filter which besides affecting the air distribution will reduce the efficiency of the refrigeration system.	Cleaning would be carried out as a function of the maintenance contract.
Yearly	03.10	Check condition and positioning of direct sensing temperature bulbs or probes.	A dirty or poorly positioned return air sensor would result in inefficient operation.	Sensors would be cleaned during the maintenance visit and would be re-fixed to their 'normal' positioned if they have become detached- as long as it was a simple matter. Sensors causing problems because they are wrongly positions would be tested during the visit as long as it was a simple matter, otherwise a cost would be given for the modification.
Yearly	O4.8	Check operation of modulating dampers and actuators	Incorrectly positioned dampers could cause incorrect air flow quantities and/or temperature which might adversely affect the efficiency.	Dampers and linkages would be lubricated during the maintenance visit.
Yearly	O4.10	Examine ducting internally for dust accumulation, corrosion and deterioration.	A dirty duct will increase the pressure drop and reduce the air flow which besides affecting the air distribution would reduce the efficiency of the refrigeration system.	Ductwork would not normally be cleaned during maintenance inspections but poor condition of the ductwork would be reported to the client and possibly costs for a specialist cleaning company to attend site.
Yearly	O4.11	Check for signs of air leakage or ingress from canvas ducts and duct connections etc.	Loss of pressure will reduce the air flow which besides affecting the air distribution would reduce the efficiency of the refrigeration system. Alternatively, the ingress of air from unconditioned	Condition would be reported to client with repair costs from duct work specialist.

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			spaces could cause inefficient operation.	
Yearly	O4.15	Check condition of duct insulation	Insulation might be missing, in poor condition/wet, or vapour seals compromised - all of which could cause loss of efficiency.	The client would be given costs for an insulation engineer to repair or replace the insulation.

Interval	ECO	Task	Reason	Actions
Fluid Chillers				
Quarterly	O3.15 O3.13	Check refrigerant flow through the sight glass.	May indicate shortage of refrigerant, a blocked drier or a poorly adjusted expansion valve as well as moisture/acid in the system. Shortage of refrigerant (bubbles in the sight glass) would result in lack of performance and lower compressor running currents but energy costs would be higher owing to longer run times. An expansion valve with a too low superheat setting (bubbles in the sight glass) might result in reduced efficiency through excessive liquid in the evaporator which could also lead to motor/compressor failure (sustainability ECO). Moisture/acid in the system could result motor/compressor failure (sustainability ECO)	Client would be advised if refrigerant was needed together with costs.
Quarterly		Ensure switches and indication lamps function correctly.	Essential so that correct operation of the system can be monitored and faults indicated.	Cost would normally be given to replace faulty indicating lamps.
Quarterly	O3.7 O3.13 O3.15	Check and record all pressure gauge readings.	Refrigerant pressure readings can give indications of shortage of refrigerant and other problems with the system.	Normally carried out on maintenance inspection.
Quarterly	O3.8 O3.12 O4.16	Check and record flow and return chilled water temperatures.	Essential to indicate correct flow rates and operation	Normally carried out on maintenance inspection.

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Interval	ECO	Task	Reason	Actions
	O4.22			
Quarterly	O3.9 O3.12 O4.22	Check and record flow and return condenser water temperatures.	Essential to indicate correct flow rates and operation	Normally carried out on maintenance inspection.
Quarterly	O3.15	Check the operating oil pressure.	Low oil pressure can be indicative of shortage of refrigerant and other problems with the system/compressors	The reason for low oil pressure would be investigated and remedied under the maintenance contract if minor 'adjustments' were required – otherwise a report and costs would be given to the client.
Quarterly	O3.15	Check the compressor oil level and condition.	Low oil level can be indicative of shortage of refrigerant and other problems with the system/compressor.	The reason for low oil level would be investigated and remedied under the maintenance contract if minor 'adjustments' were required – otherwise a report and costs would be given to the client.
Quarterly	O3.1 O3.2 O3.3 O3.5 O3.6	Reselect the operating sequence.	Configure chiller/compressor sequence/operating schedule for minimum energy usage and even running periods.	Normally 'changeover' for even running periods would be implemented – this in itself would ensure excessive, 'wear and tear', energy use would be minimized.
Quarterly	O3.15	Inspect refrigeration pipe-work	Evidence of leaks could indicate that system has lost refrigerant.	Client would be advised if refrigerant was needed together with costs.
Quarterly		Check and record the compressor/s running current.	Carried out under steady state conditions and at full compressor load will indicate chiller efficiency.	No direct action but would indicate that there was a problem which would be investigated.
Quarterly	O3.15	Check anti-vibration mountings.	Faulty AVMs or AVMs in poor condition could cause stress fractures to refrigerant pipe-	AVMs would be checked for security; serviceability and

Interval	ECO	Task	Reason	Actions
			work resulting in significant refrigerant loss.	freedom of movement. The Client would be given costs to replace any faulty or damaged AVMs.
Quarterly		Check integral control panel wiring connections.	Loose wiring could cause high running currents or bad control circuit/sensor comms.	Would be rectified under maintenance contract.
Quarterly	O3.15	Check the operation and settings of safety controls	A system cycling on a low pressure safety switch could be indicative of a shortage of refrigerant – a badly adjusted switch would disguise this.	Would be rectified under maintenance contract.
Quarterly		Check condition of refrigeration pipe-work insulation	Bare pipe work or even loss of vapour seal could cause high superheat of the suction line resulting in high motor/compressor temperatures etc which could cause higher running current.	Client would be advised and given costs of repair.
Half Yearly	O4.21	Check condition of chilled water pipe-work and insulation.	Evidence of water leaks could indicate that the system pressures are not correct. Poor or damaged insulation e.g. bare pipe or loss of vapour seal, would give rise to increased energy use.	Problems would be reported to the client along with costs for repair by specialist contractor.
Half Yearly	O3.15	Check pipe-work hangers and brackets for security.	'loose' pipe-work has the potential to cause a leak.	Normally checked on maintenance inspection.
Half Yearly	O2.3	Check trace-heater tapes.	Faulty heater tapes could cause water circuits to freeze up in low operating/ambient conditions whilst those energized when there is no possibility of a 'freeze up' would be using energy unnecessarily.	Costs would be given to repair/replace faulty heaters whilst an incorrectly set thermostat would be adjusted during the maintenance visit.
Half Yearly		Examine all electrical connections for security and no signs of overheating or arcing are present.	Bad connections will cause high running currents and possible component failure.	Connections/terminals would be tightened or remade where necessary, unless a significant cost was involved, in which case

Interval	ECO	Task	Reason	Actions
				the client would be advised.
Half Yearly		Inspect and check operation of contactors, starters motor protection devices.	High resistance, through arcing or dirt, on the contactor or relay contacts result in higher running amps and possible motor/compressor failure.	Client would be given costs to replace contactors/relays etc.
Half Yearly	O2.5 O3.4 O3.5 O3.6 O3.7 O3.8 O3.9	Check operation and setting of thermostat/controller.	Badly set up controller could cause excessive compressor running time or short cycling- both of which result in higher electricity consumption.	Adjustments would normally be made under the maintenance contract.
Half Yearly	O3.12 O3.16	Check condition of air cooled condenser coil.	For every 10K rise in condensing temperature there could be a 1.35% reduction in evaporator capacity and corresponding increase in power consumption. HARMONAC measured increase 7.65%	Condensers would normally be cleaned under the maintenance contract unless perhaps if it was excessively contaminated and needed 'heavy duty' cleaning, for instance, when for which the client would be given costs. The reason for heavy contamination would be investigated and depending on where the blame lies either the client or the contractor would responsible for the cleaning with the contractor advising of cost if appropriate. Corroded fins can be treated with coatings to prevent worsening and therefore future increases in energy

Interval	ECO	Task	Reason	Actions
				consumption; treatments such as Blygold, it is claimed, also increase the efficiency by 1-2%.
Half Yearly	O3.12 O4.12 O4.13	Check air cooled condenser fan motor bearings and lubrication.	Stiff or worn condenser fan motors would result in higher running amps and high condensing pressures-see condenser coil above. Dirty or damage fan blades could result in higher condensing temperatures and therefore higher energy input.	Client would be given costs to repair or replace fan motors. Most bearings are permanently lubricated – rarely can motors be greased. Cleaning would be carried under maintenance contract.
Half Yearly	O3.15	Check refrigerant charge.	Refrigerant charge too low would increase compressor running time and too high would result in higher run amps. Motor/compressor could fail and need replacing (sustainability ECO).	Client would be given costs to find the leak, if not found during maintenance, and replenish refrigerant.
Half Yearly	O4.19 O4.22	Check operation of chilled water pump.	Check that operating pressures are correct – too high and excessive energy would be used.	Usually the responsibility of the contractor if it is integral to the chiller.
Half Yearly	O4.20	Check water level in make-up tank or operation of pressurization unit.	Essential to maintain correct system 'fill' pressures.	Normally would be checked under maintenance contract but any repairs or adjustments would only be made if they were part of the chillers integral hydronic module – otherwise the client would be advised of the costs to rectify.
Half Yearly	O4.18	Bleed air from the hydronic distribution system.	Essential to maintain correct system 'fill' pressures.	Would normally be done as part of the maintenance inspection.
Half Yearly	O4.19 O4.22	Check operation of condenser water pump.	Check that operating pressures are correct – too high and excessive energy would be used.	

Interval	ECO	Task	Reason	Actions
Half Yearly		Inspect chilled water safety valves.	Check that they are not leaking or activating under normal operating conditions	Checked under maintenance contract but the responsibility, to repair or replace, by the contractor would be if they are integral to the chiller.
Half Yearly		Check chilled water flow switches, pressure switches etc.	Essential to confirm correct flow rates and operation.	Checked under maintenance contract.
Half Yearly	O3.10	Check temperature sensors bulbs or probes.	Dirty, damaged or inappropriate positioning sensing elements can result in incorrect operation which might result in higher energy usage.	Dirty sensor would be cleaned under the maintenance contract.
Yearly		Check chilled water filter/strainers and clean.	A blocked chilled water strainer will cause the chiller to off load or trip out on low water flow/temperature/pressure switches.	Usually the responsibility of the contractor if it is integral to the chiller, when it will be stripped down and cleaned.
Yearly	O3.12	Check condenser water filter/strainers and clean.	A blocked chilled water strainer would cause high condensing temperatures with the subsequent increase in energy input.	If only the chiller is under contract, the condenser water filter/strainer would not likely to be the responsibility of the contractor and therefore extra costs would be provided, to the client, for it to be stripped down and cleaned.
Yearly	O3.17 O3.12	Check condition of water cooled condenser.	Fouling or scaling of the tube bundle would cause high condensing temperatures with the subsequent increase in energy input.	Usually the responsibility of the contactor under the maintenance contract. Lightly fouled condensers would be cleaned with a tube brush whilst heavily fouled condensers would be 'chemically' cleaned by a specialist

Interval	ECO	Task	Reason	Actions
				contractor. Costs for the latter could be given to the client if the excessive fouling was beyond the control of the contractor.

See also refrigeration system

Interval	ECO	Task	Reason	Actions
			Refrigeration System	
Half Yearly	O3.15	Inspect all refrigeration pipe-work, connections, checking for signs of leakage or test as per current legislation	Carry out visual inspection of external surfaces for any evidence of leakage from the system. Leak checking should be carried out as per the requirements of the F-gas and ODS (Ozone Depleting Substances) Regulations, which should be at least the Indirect Leak Detection Method. Refrigerant charge too low would increase compressor running time and eventual loss of capacity, and too high would result in higher run amps. Motor/compressors could eventually fail and need replacing (sustainability ECO). HARMONAC average: 29.7% increase in energy by virtue of the longer compressor running time even though this would have been at a lower energy input.	Evidence of leakage would be followed up by a leak test with electronic leak test and any minor cost repairs rectified, normally under the maintenance contract. In the event of major problems or if the leak could not be found, the client would be advised of the further work (the refrigerant may have to be removed and the system pressurized with oxygen-free nitrogen or dye added, for instance) required, and costs given. F-Gas leaks have to be repaired as soon as possible and ODS leaks have to be repaired within 14 days.
Half Yearly	O3.15	Check all anti-vibration mountings.	Faulty AVMs or AVMs in poor condition could cause stress fractures to refrigerant pipe-work resulting in significant refrigerant loss.	AVMs would be checked for security; serviceability and freedom of movement. The client would be given costs to replace any faulty or damaged AVMs.

Interval	ECO	Task	Reason	Actions
Half Yearly	O2.5 O3.4 O3.5 O3.6 O3.7 O3.8 O3.9	Check operation and setting of thermostat/controller.	Badly set up controller could cause excessive compressor running time or short cycling- both of which result in higher electricity consumption.	Adjustments would normally be made under the maintenance contract.
Half Yearly	O3.16	Check condition of air cooled condenser coil.	For every 10K rise in condensing temperature there could be a 1.35% reduction in evaporator capacity and corresponding increase in power consumption. HARMONAC measured increase 7.65%	Condensers would normally be cleaned under the maintenance contract unless perhaps if it was excessively contaminated and needed 'heavy duty' cleaning, for instance, when for which the client would be given costs. Corroded fins can be treated with coatings to prevent worsening and therefore future increases in energy consumption; treatments such as Blygold, it is claimed, also increase the efficiency by 1-2%.
Half Yearly	O3.13 O3.15	Check operation and super heat setting of Thermostatic Expansion Valve	Suction super heat would normally be 5 to 8K (or as per manufacturers' instruction) to ensure maximum efficiency of evaporator. High superheat or hissing noise could indicate shortage of refrigerant.	Not always checked as a matter of course, especially on small systems. The decision to check SH would be dictated by other lack of performance indicators. An incorrect SH that could be corrected by adjustment of the Expansion Valve would be carried out under the maintenance contract.
Half Yearly	O3.15	Check sub cooling value	Sub cooling value would indicate correct refrigerant charge.	Not always checked as a matter of course, especially on small systems. The decision to check sub-cooling value would be dictated by

Interval	ECO	Task	Reason	Actions
				other lack of performance indicators.
Half Yearly	O3.15	Check operation of high and low pressure safety switches, and oil pressure switch.	Health & Safety A system cycling on a low pressure safety switch could be indicative of a shortage of refrigerant – a badly adjusted switch would disguise this.	Would be rectified under maintenance contract.
Half Yearly	O2.3	Check crankcase heater	An inoperative compressor crankcase heater would result in liquid refrigerant migrating to the crankcase in low ambient conditions, which would cause high starting currents, stalling completely on start up, low oil pressure due to foaming or liquid refrigerant to enter the cylinders. May cause eventual mechanical or electrical failure of the motor/compressor. Crankcase heaters left on for long periods during the heating season can consume excessive energy.	Electrical disconnection of a crankcase heater during a prolonged scheduled compressor off period would not be done unless the end user requested it-it should be noted that the restarting of the compressor should not be done without a service engineer in attendance to ensure that the crankcase heater has been energized for a suitable time, to avoid a possible catastrophic mechanical failure of the compressor and/or electrical failure in the case of a motor/compressor.
Half Yearly	O3.15	Check compressor oil level	Low oil level can be indicative of shortage of refrigerant and other problems with the system.	The reason for low oil level would be investigated and remedied under the maintenance contract if minor 'adjustments' were required – otherwise a report and costs would be given to the client.
Half Yearly		Check compressor and system line components for correct operation	Essential for maintaining integrity and operation of system	Normally carried out under the maintenance contract
Half Yearly	O3.15	Check condenser pressure controls e.g speed controller or damper	Condenser fan cycling/speed controllers and dampers, not set correctly could cause over or under condensing. Both conditions would result in poor efficiency, and therefore	Would normally be adjusted under the maintenance contract. Costs, including labour, for replacing faulty controllers etc would be given.

Interval	ECO	Task	Reason	Actions
			longer compressor running time, and under condensing would mean higher running currents also. Certain condenser fan cycling/speed modes could indicate a shortage of refrigerant.	
Half Yearly	O1.7 O2.5 O2.4 O3.5 O3.7 O3.10 O3.13 O3.11 O3.12	Carry out full diagnostic checks- operating pressures, running currents, temperatures etc.	Operating temperatures and pressures of the refrigeration system and compressor running currents would be checked and/or it would checked with manufacturer's software monitoring tool & lap top. Operating pressures of small critically charged systems would not normally be checked. The use of datalogging equipment such as Climacheck would not be used unless a specific requirement of the contract.	Minor problems, like valve adjustments, would be rectified under the maintenance contract but those, like loss of refrigerant or motor/compressor not pumping 100%, for instance, would, be subject to a cost for repair.
Half Yearly		Check electrical connections, cables conduits etc.	Bad connections could cause high running currents.	Normally rectified under maintenance contract at no cost providing it was a simple repair.
Half Yearly		Check temperature difference across liquid line drier	A temperature difference, often observed by hand (touch), across a liquid line, filter/drier would indicate a blockage resulting in refrigerant starvation in evaporator with the low suction pressure leading to a reduction in compressor efficiency and the reduced refrigerant flow in a lowering of cooling capacity.	A blocked filter/drier would be reported to the client and costs given for its replacement.

Interval	ECO	Task	Reason	Actions
			Control Panels	
Half Yearly		Inspect control panel and components for cleanliness and check that all access panels and doors are able to be closed and secured.	Health & Safety	Panel enclosure and components would normally be cleaned under the maintenance contract but costs would normally be given to repair or replace faulty door/cabinet hardware.
Half Yearly		Check panel is live, all switch selections are correct, indication lamps are functioning correctly and no alarms are present.	Health & Safety Essential so that correct operation of the system can be monitored and faults indicated.	Cost would normally be given to replace faulty indicating lamps.
Half Yearly		Examine isolator and door interlocking mechanism	Health & Safety	Costs would be given to replace faulty isolators and door interlocking mechanisms.
Half Yearly		Ensure panel enclosure vent louvres are clean and unobstructed and any ventilation fans are OK.	Overheated components etc are prone to failure and higher energy use.	Vent would be cleaned during the visit at no extra cost but costs would be given to client for the replacement of faulty fans.
Half Yearly		Check for noisy operation of contactors/relays.	Could indicate high resistance, through arcing or dirt, on the contactor or relay contacts result in higher running amps and possible fan motor or motor/compressor failure.	Armature faces would normally be cleaned, if appropriate, under the maintenance contract, but if unsuccessful or other faults existed, then costs would be given to replace the contactor.
Half Yearly		Check for satisfactory operation of contactors.	Ensure that contactor freely energises and releases and check manually for freedom of movement with power isolated.	Contacts, contact blocks or complete contactors may have to be replaced outside of the maintenance contract and therefore costs would be given to the client in respect of labour and materials.
Half Yearly		Visually check for signs of overheating of contactors.	High resistance, through arcing or dirt, on the contactor or relay contacts result in higher running amps and possible fan motor or motor/compressor failure.	Contacts, contact blocks or complete contactors may have to be replaced outside of the maintenance contract and therefore costs would be given

Interval	ECO	Task	Reason	Actions
				to the client in respect of labour and materials.
Half Yearly		Examine all electrical connections for security and no signs of overheating or arcing are present.	Bad connections will cause high running currents and possible component failure.	Connections/terminals would be tightened or remade where necessary, unless a significant cost was involved, in which case the client would be advised.
Half Yearly		Ensure motor/overloads are set correctly.	To ensure equipment is operating within its design running currents to prevent failure through overheating etc and to avoid excessive energy use.	Would be adjusted to correct settings on maintenance visit and monitored.
Half Yearly		Inspect wiring/cables for signs of decay, damage or wear.	Health & Safety Maintains integrity and operation of system.	Client would be advised of costs to rectify.
Half Yearly		Check mechanical interlocks between contactors (where fitted).	Essential to prevent motor damage and high energy use on start up.	Would be adjusted where necessary on maintenance visit
Half Yearly		Check transition time of Star-Delta and Part Winding starters	Essential to prevent motor damage and high energy use on start up.	Would be adjusted where necessary on maintenance visit
Half Yearly		Check transformers-resistors for signs of overheating.	Maintains integrity and operation of system	Client would be advised of costs to rectify if necessary.
Half Yearly		Check fuses/electrical protection devices are in good condition and are rated correctly.	Health & Safety To ensure equipment is operating within its design running currents to prevent failure through overheating etc and to avoid excessive energy use.	Would be adjusted to correct settings on maintenance visit and monitored.
Half Yearly	O2.5 O3.4 O3.5 O3.6 O3.7	Check operation and setting of thermostats/controllers.	Badly set up controller could cause excessive compressor running time or short cycling-both of which result in higher electricity consumption.	Adjustments would normally be made under the maintenance contract.

Interval	ECO	Task	Reason	Actions
	O3.8 O3.9			
Roof Top, Large Packaged and Central Plant				
Half Yearly	Use combinations of the following depending on system configuration: • A/C Split & Small Packaged • AHUs • Ductwork • Liquid Chillers • Refrigeration systems • Control panels			

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