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Date: September 10, 2012

To: The SCE ISP evaluation team
SCE

From: Dennis Rowan PE
ASW Engineering Management Consultants

Re: Investigations of Energy Efficiency Measures and Industry Standard Practice (ISP)
[HVAC Preventive Maintenance, Report Project ISP-0022]

After reviewing the provided project documents, expert opinions, and research, ASW can recommend whether the proposed HVAC measures should be considered routine preventive maintenance and as such Industry Standard Practice (ISP). There are three scenarios to contemplate regarding this question.

1. **Stand Alone Measures** – ASW recommends that SCE consider the HVAC measures denoted as “Yes” in the Findings column of Table 2 to be standard preventive maintenance, and therefore ISP. Even though there are energy savings associated with regular maintenance for many of these measures, as compared to facilities that do not conduct regular maintenance, the energy savings associated with the findings in Table 2 are considered to be ISP. HVAC measures denoted with a “No” are not considered to be preventive maintenance, and therefore not ISP.
2. **Comprehensive Maintenance Package** – While Table 2 addresses these measures individually, it is also noted that these measures can be combined as part of a more comprehensive approach to facility maintenance. This type of comprehensive approach is widely adopted and implemented throughout the industry and was also found to be industry standard practice for the measures denoted as “Yes” in Table 2. Whether these measures are independently implemented, or part of a more comprehensive maintenance plan, this study recommends that SCE consider them to be ISP. As with the individual approach, any accompanying energy savings from these ISP measures is also considered to be ISP.
3. **Enhanced Maintenance for Energy Efficiency** – The results in Table 2, individual or comprehensive, do not include energy performance based objectives and are based only on preventive maintenance, thermal comfort, and indoor air quality. Enhanced Maintenance for Energy Efficiency can be applied to these measures but is not currently part of the industry standard preventive maintenance programs that facilities typically incorporate into their operating strategy. If the performance objective of enhanced energy efficiency is added to the comprehensive maintenance plan, then there are measures that can be implemented at an accelerated or enhanced level that create additional energy efficiency beyond the industry standard maintenance program. These performance levels for energy efficiency are measure and site specific. ASW recommends that SCE require a case-by-case evaluation to determine if the proposed measures at any particular site are Enhanced Maintenance for Energy Efficiency, and as such, accelerated or enhanced beyond Industry Standard Practice for the particular site.

PROJECT DISCUSSION

SCE requested that ASW Engineering provide a short-term study to determine if certain HVAC maintenance measures are considered to be routine maintenance. The evaluation considered 49 separate HVAC measures for review that ranged from replacing air filters to trimming pump impellers. The HVAC industry typically uses

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the terms “preventive” and “routine” interchangeably when considering the maintenance measures on HVAC systems. This study uses the term “preventive maintenance” instead of “routine maintenance” to maintain consistency with industry practice.

The Northwest Energy Efficiency Council defines preventive maintenance as “the tracking of repairs and service on equipment, and the study of breakdowns in order to prevent them.” The California Commissioning Guide for Existing Buildings states that preventive maintenance is a critical strategy for long-term HVAC system energy-efficient performance. In addition to maintaining efficiency, a preventive maintenance program serves to improve HVAC system reliability and increase equipment life. ASHRAE Standard 180 establishes minimum HVAC inspection and maintenance requirements that preserve a system’s ability to achieve acceptable thermal comfort, energy efficiency, and indoor air quality in commercial buildings.

Many building operators and service companies employ preventive maintenance programs as part of their standard practice and their programs include many of the evaluated measures. In some cases, the measures include inspection of the equipment for any needed repairs. If these inspections uncover any needed repairs, then the repairs can be completed. In these cases, it is not the repair that is the frequent occurrence, rather it is the inspection that occurs on a regular basis, and the repairs occur as required as a result of the regular inspections.

In some instances, the concept of preventive maintenance can be taken further than just equipment longevity, where enhanced-maintenance can produce energy efficiency. For example, if a bank of air filters, in a typical VAV system, requires periodic changing every six months because of environmental conditions, then changing these same filters every three months may provide an incremental increase in energy efficiency during the three months when the old filters would have remained in place by the standard maintenance interval. The ‘Enhanced Maintenance for Energy Efficiency Program’ provides the incremental energy savings. This is a site specific concept since each site has its own unique requirements with regard to preventive maintenance intervals. If this same filter bank were in a location that required filter changes every three months, due to environmental reasons, then the three month cycle would not improve energy efficiency because it is the normal maintenance interval. In order to save energy at the second location, a monthly filter change frequency might be required to attain the energy efficiency. Each location would pose unique, site specific issues that would need to be addressed within the enhanced maintenance plan in order to facilitate energy efficiencies beyond the standard preventative maintenance plans.

METHODOLOGY

To determine if the proposed HVAC maintenance measures are considered to be standard preventive maintenance as compared to enhanced energy saving maintenance, ASW analyzed the available project information, researched typical preventive maintenance measures, gathered literature, and conducted phone interviews with subject matter experts.

ASHRAE Standard 180-2008, “Standard Practice for Inspection and Maintenance of Building HVAC Systems,” addresses the proposed HVAC measures and specifies frequency of inspection and maintenance procedures. Standard 180 describes a fairly comprehensive level of maintenance for commercial building HVAC systems. Performance objectives shall incorporate thermal comfort, energy efficiency, and indoor air quality metrics and be based on basis of design and operational criteria specific to a particular system. Standard 180 states that the following are valid sources that may assist in the establishment of specific performance objectives based on basis of design and operational criteria specific to a particular system.

1. Design documents for the system with the provision that those documents still reflect the current loads, space utilization and other system requirements

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2. A duly licensed individual authorized to perform HVAC design work
3. Manufacturers' technical material or generally accepted industry criteria
4. Guidance from ASHRAE Standards 55, 62.1 and 90.1
5. Authority having jurisdiction
6. Contractor, professional engineer
7. Owner's Program Requirements

Enhanced Maintenance for Energy Efficiency

ASHRAE Standard 180 identifies energy efficiency as an incorporated performance objective. For the purposes of this study, it has been isolated and it is described as Enhanced Maintenance for Energy Efficiency. The industry experts consulted for this study were asked if they commonly implemented this type of Enhanced Maintenance for Energy Efficiency in their buildings. Their replies were in agreement that most of their buildings did not implement this approach. Some indicated that lease agreements do not create a benefit from this approach when energy costs are passed through to the tenant while maintenance costs are absorbed by the owner. When asked if they thought other building maintenance programs were currently implementing this approach of Enhanced Maintenance for Energy Efficiency, they responded that, if so, it was not many. We asked if they would expect that other buildings would implement this approach of Enhanced Maintenance for Energy Efficiency. The response was that buildings with dedicated staff are more likely to implement this strategy, but that no population would implement it unilaterally.

We finally asked if there was a shift towards this approach of Enhanced Maintenance for Energy Efficiency. The indication was that there was indeed a shift in this direction and that the industry was slowly adopting this type of approach. Sources stated that operators are aware, but their awareness is limited. Existing maintenance scheduling systems are already in place and these systems are difficult to change.

Comprehensive Packages and Stand Alone Maintenance

ASHRAE Standard 180 was used as the benchmark for HVAC maintenance programs and was compared with the following HVAC literature.

The Preventive Maintenance & Operations handbook, published by the Northwest Energy Efficiency Council, provided general industry standard preventive maintenance procedures. The handbook recommends cleaning light fixtures, lamps, and lenses every 6 to 24 months depending on the environment. Additionally, preventive maintenance for rooftop package units and air handling units includes lubricating fan motors, inspecting fan belts for tension and excessive wear, and sealing air distribution system leaks on a regular basis. These HVAC measures are considered, by this source, to be preventive maintenance because they are recommended on a regular basis. ASHRAE Standard 180 does not contradict this source.

Trane has published an online Preventive Maintenance Checklist for outdoor HVAC units. This provides a list of items that a service technician should provide on a routine basis. Some HVAC preventive maintenance procedures include the inspection of the proper refrigerant level and adjustment if required, the inspection of the cooling coils and clean if required, and inspection of the fan motor and blades for wear and damage and replace or lubricate as needed. These HVAC measures are considered, by this source, to be preventive maintenance because they are recommended to be conducted on a regular basis. This source is also in alignment with ASHRAE Standard 180.

Finally, a research paper titled "Retrocommissioning's Greatest Hits," published by Portland Energy Conservation, Inc. (PECI), was reviewed. PECI is a company that provides energy savings solutions in the residential and commercial industries. The research paper used utility and government funded studies to

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summarize retro-commissioning measures that significantly improve building's operation and maintenance practices. The measures that were addressed were considered to provide significant energy savings in retro-commissioning projects and are not considered to be preventive maintenance by this source. Some of the measures include:

- Trimming condenser pump impellers
- Adjusting the supply air temperature set point
- Optimizing economizer control
- Fixing hot water pipe leaks and chilled water valve leaks
- Resetting the static pressure for air handling units

Three major HVAC service companies along with a design-build mechanical engineering firm were contacted to assess the HVAC measures from a field perspective. These companies were asked if the proposed HVAC measures are considered to be preventive maintenance according to what typically is practiced in the field. They were asked to provide typical frequencies for these measures to be cycled along with their assessments of the measure applicability to a preventive maintenance program. They were also asked if these measures were considered standard preventive maintenance as individual measures or as part of a comprehensive maintenance package. The measures were consistently identified by the respondents regardless of their inclusion in a comprehensive program or not. That is to say, their results are not dependent on them being implemented individually or as part of a comprehensive preventive maintenance program.

The respondent answers are listed in the results section, below. The findings are a compilation of the sources.

RESULTS

Table 2 represents the HVAC preventive maintenance findings for each of the interviewed experts, researched literature, and previous SCE findings. A "Yes" represents a HVAC maintenance measure that is considered to be preventive maintenance and a "No" represents a HVAC measure that is not considered to be preventive maintenance. The recommended findings indicate the cumulative answer from the literary research and field perspective.

The Table 2 results do not include energy efficiency performance based objectives and are based only on preventive maintenance, thermal comfort, and indoor air quality. Energy Efficiency is not generally considered as a primary objective when a facility is designing a maintenance plan. Enhanced Maintenance for Energy Efficiency can be applied to the measures in Table 2 but is beyond the scope of standard preventive maintenance. Maintenance intervals are site specific and are not itemized in Table 2.

Table 2: HVAC Preventive Maintenance Findings

Is the HVAC measure preventative/routine maintenance?							
#	Measures	Source 1	Source 2	Source 3	Source 4	Source 5	Findings
1	Replace air filter with same - unitary AC	Yes	N/A	Yes	Yes	Yes	Yes

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Is the HVAC measure preventative/routine maintenance?							
#	Measures	Source 1	Source 2	Source 3	Source 4	Source 5	Findings
2	Replace air filter with same- built up systems	Yes	N/A	Yes	Yes	Yes	Yes
3	Clean air filter - unitary AC	Yes	N/A	Yes	Yes	Yes	Yes
4	Clean air filter - built up system	Yes	N/A	Yes	Yes	Yes	Yes
5	Replace air filter with high performance filter - unitary AC	No	N/A	No	No	No	No
6	Replace air filter with high performance filter - built up systems	No	N/A	No	No	No	No
7	Clean evaporator coils -unitary AC	Yes	No	Yes	Yes	Yes	Yes
8	Clean evaporator coils - built up system	Yes	Yes	Yes	Yes	Yes	Yes
9	Clean condenser coils - unitary AC	Yes	Yes	Yes	Yes	Yes	Yes
10	Clean condenser coils - built up system	Yes	Yes	Yes	Yes	Yes	Yes
11	Clean condenser scale using manufacturer's recommendations	Yes	N/A	Yes	Yes	Yes	Yes
12	Clean cooling tower media	Yes	N/A	Yes	Yes	Yes	Yes
13	Replace cooling tower media with new media	No	N/A	No	No	No	No
14	Replace cooling tower water filter	Yes	N/A	Yes	Yes	Yes	Yes
15	Replace existing cooling tower water treatment	Yes	N/A	Yes	Yes	Yes	Yes
16	Repair economizer - unitary AC	Yes	No	No	No	No	No

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Is the HVAC measure preventative/routine maintenance?							
#	Measures	Source 1	Source 2	Source 3	Source 4	Source 5	Findings
17*	Repair economizer - built up system	Yes	Yes	No	No	No	No
18*	Adjust minimum outdoor air damper position	No	No	Yes	Yes	Yes	No
19*	Clean air ducts - unitary AC	Yes	No	Yes	Yes	No	No
20*	Clean air ducts - built up system	Yes	No	Yes	Yes	No	No
21	Seal air ducts - unitary AC	No	No	Yes	No	No	No
22	Seal air ducts - built-up system	No	No	Yes	No	No	No
23	Replace air ducts - unitary AC	No	No	No	No	No	No
24	Replace air ducts - built up system	No	No	No	No	No	No
25	Repair VAV boxes	No	No	No	No	No	No
26	Perform air balance - unitary AC	No	Yes	No	No	No	No
27	Perform air/water balance - built up system	No	Yes	No	No	No	No
28	Lock the thermostat from public access - unitary AC	N/A	N/A	No	No	No	No
29	Lock the thermostat from public access - built up system	N/A	N/A	No	No	No	No
30	Reprogram thermostats - unitary AC	No	No	No	No	No	No
31	Reprogram thermostats - built up systems	No	No	No	No	No	No

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Is the HVAC measure preventative/routine maintenance?							
#	Measures	Source 1	Source 2	Source 3	Source 4	Source 5	Findings
32	Replace fan belts with high efficiency belts	No	Yes	No	No	No	No
33	Adjust or refit fan belts	Yes	Yes	Yes	Yes	Yes	Yes
34	Lubricate motors, pumps or blower fans - unitary AC	Yes	Yes	Yes	Yes	Yes	Yes
35	Lubricate motors, pumps or blower fans - built up system	Yes	Yes	Yes	Yes	Yes	Yes
36	Trim pump impeller	No	No	No	No	No	No
37	Replace fan motor with new motor	No	No	No	No	No	No
38	Replace or repair fan blades	No	No	No	No	No	No
39*	Clean blower or fans - unitary system	Yes	No	Yes	No	Yes	No
40*	Clean blower or fans - built up system	Yes	No	Yes	No	Yes	No
41	Adjust refrigerant level - unitary system	No	No	No	No	No	No
42	Adjust refrigerant level - built up system	No	No	No	No	No	No
43	Repair cooling tower leaks - built up system	No	No	Yes	No	No	No
44	Repair cooling medium piping leaks - built up system	No	No	Yes	No	No	No
45	Repair refrigerant piping leak - unitary AC	No	No	Yes	No	No	No
46	Repair evaporator coil leaks - built up system	No	No	Yes	No	No	No

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Is the HVAC measure preventative/routine maintenance?							
#	Measures	Source 1	Source 2	Source 3	Source 4	Source 5	Findings
47	Repair evaporator coil leaks - unitary AC	No	No	Yes	No	No	No
48	Repair condenser coil leaks - built up system	No	No	Yes	No	No	No
49	Repair condenser coil leaks - unitary AC	No	No	Yes	No	No	No

*Several of the measures were identified as borderline and could be considered “close calls”. If the industry experts do not agree, then the conclusion of this study is that there is no standard practice of having the measure as part of a preventive maintenance program. These are identified as Measures 17, 18, 19, 20, 39, and 40.

Even though the identification of the requirement for repairs/maintenance may be based on a regular inspection process, the repair/maintenance may not be the frequent occurrence and may not meet the criteria of regular or preventive maintenance. This is the case for items 41 through 49 in Table 2: HVAC Preventive / Routine Maintenance Findings. The inspection of these items occurs as part of a preventive maintenance program and when there are maintenance issues identified through these inspections, those issues are addressed. The frequency of the repairs is not consistent with any regular intervals and cannot be classified as regular or preventive maintenance even though the inspection of these systems is part of the regular inspection program.

CONCLUSIONS

After reviewing the provided project documents, expert opinions, and research, ASW can recommend whether the proposed HVAC measures should be considered routine preventive maintenance and as such Industry Standard Practice (ISP). There are three scenarios to contemplate regarding this question.

1. **Stand Alone Measures** – ASW recommends that SCE consider the HVAC measures denoted as “Yes” in the Findings column of Table 2 to be standard preventive maintenance, and therefore ISP. Even though there are energy savings associated with regular maintenance for many of these measures, as compared to facilities that do not conduct regular maintenance, the energy savings associated with the findings in Table 2 are considered to be ISP. HVAC measures denoted with a “No” are not considered to be preventive maintenance, and therefore not ISP.
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comfort, and indoor air quality. Enhanced Maintenance for Energy Efficiency can be applied to these measures but is not currently part of the industry standard preventive maintenance programs that facilities typically incorporate into their operating strategy. If the performance objective of enhanced energy efficiency is added to the comprehensive maintenance plan, then there are measures that can be implemented at an accelerated or enhanced level that create additional energy efficiency beyond the industry standard maintenance program. These performance levels for energy efficiency are measure and site specific. ASW recommends that SCE require a case-by-case evaluation to determine if the proposed measures at any particular site are Enhanced Maintenance for Energy Efficiency, and as such, accelerated or enhanced beyond Industry Standard Practice for the particular site.

A table showing if HVAC Maintenance is ISP for a given installation type is not applicable to this project, and therefore is not included.