AUSTRALIAN DISHWASHER ROUND ROBIN TESTING TO THE IEC60436 ED. 4 STANDARD

Results of a round robin of four independent Australian test laboratories testing two dishwashers to the IEC60436 Edition 4 standard in 2016-17

Prepared by Energy Efficient Strategies for the Australian Government Department of the Environment and Energy and the E3 Committee

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Report prepared for:

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Introduction

Background

Governments have proposed that, where appropriate, Australia and New Zealand will harmonise their test standards for whitegoods appliances with international standards. Presently, suppliers are required to demonstrate that their dishwashers comply with the *Greenhouse and Energy Minimum Standards (Dishwasher) Determination 2015* legislative instrument (and the relevant New Zealand regulation) through the test procedure specified by AS/NZS 2007.1[1]. To build capacity in Australian test facilities, round robin testing of the International Electrotechnical Commission (IEC) test procedure IEC60436 *Electric dishwashers for household use - Methods for measuring the performance* (Edition 4) standard was undertaken in 2016-17. The round robin also aimed to provide confidence in any potential future compliance and enforcement activities following harmonisation with international standards.

This report summarises the data and results from the Australian round robin of dishwashers tested to IEC60436 Edition 4 published by the IEC. The round robin was initiated and funded by the Department of the Environment and Energy and the Equipment Energy Efficiency (E3) Committee, with four independent, National Association of Testing Authorities (NATA) accredited test laboratories participating.

This round robin builds on a larger international round robin sponsored by the IEC in 2015-16. The two test machines (Miele unit and Siemens unit) were supplied by the IEC. However, a fault developed in the Miele test unit during preliminary tests and the IEC supplied Miele unit was replaced with a different Miele model, kindly supplied by Choice from their existing test dishwasher stock.

The round robin was contracted through the Department of the Environment and Energy. While laboratories were paid a fixed fee for their work, they also contributed significant in-kind effort to the round robin. Energy Efficient Strategies was engaged as the project manager and sub-contracted the participating test laboratories. The round robin had many goals including to:

- Provide experience for those facilities charged with undertaking verification testing to Australian and New Zealand laws to gain practical testing experience with the relevant IEC test procedure for dishwashers, which is likely to be the proposed testing basis for energy labelling in the future;
- Build testing capacity within local test laboratories;
- Assess the reproducibility and repeatability of the IEC test method and provide expert opinions as to its technical suitability as a basis for future regulation in Australia and New Zealand;

[1] Standards Australia (2005) *AS/NZS 2007.1:2005 Performance of household electrical appliances - Dishwashers - Methods for measuring performance, energy and water consumption*

- Generate data and conduct analysis in order to provide technical feedback to the IEC with respect to any specific weaknesses or issues in the IEC test method prior to its adoption in Australia and New Zealand; and
- Give stakeholders confidence that the new test procedure gives sound results suitable for regulatory enforcement.

The Australian and New Zealand governments have long standing policies of adopting IEC and ISO test methods wherever appropriate. Australia and New Zealand energy efficiency agencies are therefore likely to propose adopting the new IEC test method for energy consumption and performance of household dishwashers (IEC60436) in the future.

In order to "road test" the IEC standard, the round robin used the published version of IEC60436 Edition 4 as the basis for testing, with only minor modifications (mostly relating to the specification of local values for voltage, frequency and water hardness relevant to Australian conditions, as permitted in the standard). The participating test laboratories were able to examine the IEC test procedure very closely and had the opportunity to highlight practical issues surrounding testing in order to provide feedback to the international committee. These issues have been compiled in this report and have been submitted to the IEC SC59A committee (electric dishwashers) for its consideration.

Test Results

The round robin yielded substantial information regarding the IEC test method. The data collected also allowed some limited benchmarking back to the Australian and New Zealand test method, currently used for local regulation. This data will be useful during the transition to the IEC test method. Details are set out later in this report.

The results were encouraging in the context of the possible policy goal of using the IEC test method for regulatory purposes in the future. The round robin results provide confidence to regulators and industry stakeholders that the IEC test method provides a sound basis for re-regulation of household dishwashers. The round robin generated detailed data that can be used to commence the transition process to adopt IEC60436 for dishwashers in our region. A later section in this report contains recommendations concerning changes in IEC60436 that the IEC is encouraged to consider.

Regulatory Context

IEC committee SC59A (electric dishwashers) published IEC60436 Edition 4 in October 2015. Edition 4 included a number of changes and improvements compared to Edition 3 (2004) with Amendment 1 (2009) and Amendment 2 (2012) as set out below:

- Edition 3: published in 2004
- Edition 3 Amendment 1: 2009 – small editorial changes, addition of Type 2 reference machine (G1222 SC)
- Edition 3 Amendment 2: 2012 – small editorial changes, addition of new serving pieces, addition of standby power, revised specification for thermal oven
- Edition 4: 2015 – many editorial and some technical changes, combined cleaning and drying evaluation, new load items, new detergent D, annexes for the evaluation of soil sensing programmes, rinsing performance, dishwasher filtration and an annex on the inlet water temperature influence on energy consumption.

IEC60436 is now in the process of being adopted in Europe (with some significant modifications).

Australia and New Zealand have used AS/NZS2007.1 (and its predecessor) as the test method for dishwashers ever since energy labelling commenced in 1989 (for Australia). When AS2007 was first published in 1988, IEC60436 Edition 2 (published in 1981) was used as a template and most of the standard was aligned with that IEC edition. The current 2005 edition of AS/NZS2007.1 was prepared in parallel with IEC60436 Edition 3 and many parts of the text are common. The main technical differences between these standards are set out in a later section.

In Australia and New Zealand, regulations reference AS/NZS2007.2 for performance and energy labelling requirements. This includes setting out mandatory minimum performance requirements for cleaning and drying, energy labelling measurements and star rating algorithm and inclusion of standby power into the label energy consumption. AS/NZS2007.2 also mandates a single test on three different units for energy labelling.

Australia and New Zealand have long standing policies to adopt international test methods where this is appropriate and practical. Given that dishwasher energy testing may move to the IEC test method in the future, this round robin provided a good opportunity to closely examine the IEC test method and to identify any issues in its adoption for use in energy labelling.

Dishwashers Tested in the Round Robin

Two models of dishwasher were initially selected to be included in the round robin. The products were selected on the basis that they were the two units used in an IEC round robin test program. As noted earlier, one of the units (unit "B") developed an irreparable fault and as such was replaced by a similar unit (unit "C", also a Miele unit with a similar basket configuration), supplied by Choice. The cooperation and support offered by Choice in providing a replacement machine for the round robin at short notice is gratefully acknowledged. The two test models were:

- Machine A – Bosch/Siemens 12 place setting dishwasher, model SN26N293EU (note the name plate has been removed and replaced with a label that says Siemens RRT2014BSH 3)
- Machine C – Miele 12 place setting dishwasher model G 4203i (note this is a model supplied to the Australian market and was substituted for the European test Machine B).

In addition to the test units, as per the requirements of the test standard, reference machines were also run in parallel with the test machines during each test. Two of the laboratories owned both the older type reference machine (Type 1 - as specified in Edition 3 of the IEC standard) and the newer type reference machine (Type 2 - as specified in Edition 4 of the IEC standard) and in these cases both reference machines were run in parallel with the test machines. The other two laboratories had only the older type reference machine (Type 1), which were run in parallel with the test machines as a reference. Each laboratory used their existing in-house reference machines. The reference machines used were:

- Reference machine Type 1 – Miele G590 (available in all four labs)
- Reference machine Type 2 – Miele G1222 SC Reference (available in only two labs).

Participating Test Laboratories

The laboratories which participated in the round robin included:

- SGS (Melbourne)
- VIPAC (Melbourne)
- Choice (Sydney)
- AGA (Melbourne).

All of the test laboratories that participated in the round robin have considerable experience in testing to AS/NZS2007.1 and all were equipped to deal with the requirements of that specific standard. The four independent test laboratories were all accredited to test in accordance with AS/NZS2007.1 by the NATA. In general terms, the technical requirements within IEC60436 are generally similar to AS/NZS2007.1, so laboratories generally had no problems meeting the requirements of the test specification and the IEC standard. If the IEC becomes the mandated test method in Australasia, the local test laboratories should have no difficulty in configuring their labs and equipment to fully comply with the requirements.

The test labs were able to access expert advice from EES when conducting their respective tests. This allowed issues to be handled consistently across facilities and provided a transparent process during the round robin. All testing requirements were set out in a detailed specification (see Appendix A). Prior to testing, all laboratory testing personnel participated in a training workshop to become familiar with the differences between the current AS/NZS standard and the IEC standard, in particular with respect to soil preparation and application.

All of the participating test laboratories were paid a fee to undertake the necessary tests and to participate in a workshop after testing had been completed. In the workshop, participants shared their experience of testing to the IEC standard with other laboratories. Participating test laboratories generally found the IEC standard to be usable and generally consistent and clear. Participating laboratories were asked to provide written feedback on their experiences with the IEC test method. In particular, they were asked to identify any text in the IEC standard that was incorrect, unclear or ambiguous. Suggestions and changes have been compiled and these are included in a separate section later in this report. These comments have been submitted to IEC SC59A for further consideration.

Testing Specification and Test Method

Differences between IEC and AS/NZS

In terms of the physical testing requirements, the differences between IEC and AS/NZS are relatively minor. Essentially a test dishwasher and a reference dishwasher are operated in a room under controlled conditions with a specified load and specified soils applied to that load. The machines are operated on specified programs until each machine reaches the termination of the program.

Upon termination of the program the load is removed and a visual assessment of each load item is undertaken. Assessments are undertaken for both drying performance and then cleaning performance and each load item is awarded a score based on the visual inspection process. The aggregated scores obtained from the test machine are then compared to the reference machine to determine the drying and cleaning indexes (i.e. the test machines score expressed as a % or ratio of the score obtained by the reference machine). The IEC and AS/NZS evaluation systems for cleaning and drying performance are the same.

During the testing process both energy consumption and water consumption (cold and hot, if any), are also measured.

There are of course many small details that differ between IEC and AS/NZS, so the results for each test method are not completely comparable. However, many of these differences are somewhat arbitrary and the absolute values selected for many parameters are not terribly important. What is critical is that the test method provides sufficient and accurate data to provide insight into how consumers may use their appliances in the home. The method also needs to be robust and accurate to provide regulators with a sound basis for the local mandatory energy labelling scheme.

There are a significant number of small technical differences between the existing AS/NZS method and the IEC test method for dishwashers. Some of these are listed below. Most of these are not expected to have a substantive impact on the measured energy consumption or the product performance measurements.

Table 1: Summary of differences between IEC60436 (Ed 4) and AS/NZS2007.1

IEC clause	Parameter	IEC requirement	AS/NZS requirement	Energy impact	Notes
5.3.2.1	Voltage	Rated ± 2%	230 V± 2% or 240V where specified	None	Effectively the same requirement except that AS/NZS still allows 240V only machines to be tested at 240V
5.3.2.2	Frequency	Rated ± 1%	50 Hz ± 1%	None	Effectively the same requirement
5.6.2	Cold water temperature	15°C ± 2K	20°C ± 2K	Small	IEC will be higher energy (see detailed discussion below)
5.6.2	Hot water temp	60°C ± 2K	60°C ± 2K	None	Hot water is not generally used
5.6.4	Water pressure	240 kPa ± 20	320 kPa ± 20	None	Some dishwashers use timed fill so a small pressure range warranted
5.6.3	Hardness	Soft or hard Soft = ≤0.85 mmol/L	$CaCO_3$ (45 ±5) ppm (=0.45 mmol/L)	None	AS/NZS requirement fits within the IEC definition for soft water
5.5	Air temp	23°C ± 2K [1]	20°C ± 2K	Small	Test condition. See note 1.
5.5	Humidity	55% ± 10%	60% ± 5%	Very small	AS/NZS range is a subset of the IEC range
5.7	Detergent	IEC Type D	AS/NZS detergent (basic formulation)	None	May have a minor impact on cleaning performance

IEC clause	Parameter	IEC requirement	AS/NZS requirement	Energy impact	Notes
5.7	Detergent dose	8g + no. place settings * 1g (max)	5g pre-wash + 20g in main	Very small	For the 12 place setting dishwashers used in this round robin the doses of detergent are the same. AS/NZS is manufacturer recommendation with a cap = IEC
5.8	Rinse Agent	IEC Rinse Aid III	AS/NZS specification	None	May have a very small impact on drying performance
6.2.1 Annex A	Test load items	Similar to IEC Ed. 3 but now Ed. 4 includes some plastic bowls/plates (melamine) (more mixed load)	Effectively same as IEC Edition 3 but excluding serving items	Very small	Thermal mass will have a small impact. Slightly reduced soil load in AS/NZS so may have a small impact on cleaning performance
6.3	Soiling agents	Minced meat Tea Milk Egg Yolk Oat flakes Spinach Margarine	Tomato Juice Tea Skim milk Egg Yolk Infant cereal Spinach Margarine	None	May impact marginally on cleaning performance. Oat flakes and infant cereal are conceptually similar but different when prepared. Application slightly different for some soils but impact should be small overall. See note 2. Milk is not used as a separate soil in AS/NZS. Milk is cooked in microwave in IEC
6.4	Drying of soiling agents	Oven or air dry options.	Air only No use of microwave	Very small	Moderate impact on raw cleaning scores. Air drying is the same.
7	Evaluation process	Combined cleaning and drying	Separate cleaning and drying	Small	In AS/NZS the drying performance is an absolute measure and can therefore be undertaken as a separate test. See note 3.
7.1	Lighting conditions	3500-4500K 1000-1500 lux	3500-4500K 1000-1500 lux Lighting box recommended	None	Effectively the same
7.3	Test series	5 runs minimum	Not specified (note 4)	Small	Large lab cost, IEC only improves the estimate on a single machine, no information on the population
Annex I	Reference machine	Miele G 1222 SC*	Miele G590 (note 5)	Small	* Note: IEC Edition 4 permits the use of Miele, Model No. G590 or G595 if equivalence can be demonstrated
Annex I	Reference program	EN/IEC Universal 65°C	Gentle 45°C	None	Some impact on cleaning index

Note 1: All IEC wet product standards now specify an ambient room temperature of 23°C (these were all 20°C until the late 2000s). This small change in ambient temperature and associated humidity will have some energy impact when dishwashers are tested under IEC and AS/NZS due to initial thermal mass of the load and dishwasher. See later analysis.

Note 2: In addition to some differences in the types and specifications of soils, there are also some differences in the application techniques.

Note 3: IEC Edition 4 allows the cleaning and drying evaluation to be combined in a single test run. This potentially reduces the number of runs that need to be undertaken when doing a full performance evaluation. However, it does present some logistical challenges for test laboratories. Drying evaluation is time critical as the load is hot at the end of the program and water quickly evaporates. Edition 4 requires that drying evaluation be commenced 30 minutes after the completion of the cycle (NOT program) and that all items are evaluated in an average time of 8 sec per item, which includes a 3 sec viewing time for evaluation. Once assessed, items then need to be stacked for a later cleaning evaluation, taking care not to disturb any soil that may be present. The participating laboratories in the round robin found this to be workable.

Note 4: While AS/NZS2007.1 is a type test (single run on a single test machine), energy labelling regulations require a minimum of one test on three separate machines.

Note 5: The base assumption is that the G1222 SC using the IEC/EN reference program and the G590 on the Universal 65°C program provides equivalent cleaning performance benchmarks.

Some discussion on each of the key parameters is provided below.

Cold water supply temperature: Typically a modern dishwasher imports 10 – 20 litres of cold water and around half of this is then heated during selected operations within the cycle. In the current AS/NZS standard this cold water is imported at 20°C but in the IEC standard it is imported at 15°C. As the majority of energy used by a dishwasher relates to heating, this difference in input water temperature will have some impact on the measured energy consumption. To assess this, the round robin machines were examined. Both test machines had two heated fills. These appear to be approximately 3.5 to 4 litres each. For Machine A, stored water on board is used for the first fill and this will be at 23°C while for Machine C the incoming water will be approximately 15°C. Analysis of the laboratory data showed that the expected energy impact of the change in water temperature is likely to be quite small as set out in Table 2.

Table 2: Estimated impact of water temperature on energy consumption for test dishwashers

Machine	Operation	Inlet °C	Bath temp °C	Litres	IEC water energy Wh	AS/NZS water energy Wh
A	Wash	23	46	3.5	94	106
C	Wash	15	55	4	186	163
A	Rinse	15	65	3.5	203	183
C	Rinse	15	70	4	256	233

Notes: Wash inlet water temperature for Machine A is assumed to be room temperature (storage tank). AS/NZS water supply and room temperature is assumed to be 20°C.

For Machine A, the total energy associated with heating processes (element on) was 850 Wh, which was 90% of the total electrical energy consumed during its whole cycle. Similarly for Machine C, the total energy associated with heating (element on) was 1,230 Wh, which was also 90% of the total electrical energy consumed. However, as can be seen from Table 2, the energy associated with water heating in each machine is relatively small and makes up only about one third of the heating energy. The remaining energy must be associated with changes in the thermal mass of the load and the dishwasher itself. The energy impact of the change in water inlet temperature from AS/NZS to IEC for Machine A is estimated to be an increase of around 1% and for Machine B an increase of around 3%. The difference in thermal mass of the load at the start of the test under AS/NZS will also have an additional impact (see next point).

With respect to re-grading of local star ratings during a transition to the IEC standard, this small energy difference will need to be taken into account.

Ambient air conditions: There are some small differences between IEC and AS/NZS, but the energy impacts will generally be small. The mass of the IEC load is nominally 18.8 kg and when the specific heat capacity is applied to each item, the thermal mass of the load is about 17.5 kJ/K or 4.7 Wh/K for 12 place settings. At an initial temperature of 23°C in IEC compared to 20°C in AS/NZS, this equates to around 15 Wh difference. There will also be some additional impact of the thermal mass of the dishwasher (not estimated, but this issue is examined later). The data above suggests approximately one third of the electrical heating energy is associated with each of water heating, load heating and dishwasher heating (dishwasher itself including components, pumps, liner, racks and so forth). As AS/NZS has a colder ambient temperature than IEC, the change from AS/NZS to IEC will reduce the energy associated with thermal mass and these impacts are expected to more than cancel out the impact of water supply temperature. The impact on each dishwasher will vary depending on whether the initial operation is heated (or not) or whether there is on board water storage. Where the initial operation is not heated, some energy from the load and the dishwasher will be removed in the initial drain water.

Small differences in ambient temperature and humidity will have only a very small impact on the air drying process and consequently on raw cleaning performance scores. Room relative humidity is the most important factor that affects the rate of drying. Changes in relative humidity are not expected to have any significant impact on the final equilibrium moisture content of the soil. Humidity may also have some impact on the drying performance score.

Evaluation Process: As noted previously, the IEC standard specifies a combined drying and cleaning evaluation process. There was concern early on that this arrangement may prove to be overly onerous. However, each laboratory managed to execute the task without problem. Typically three staff members would be involved in the evaluation as follows:

- Staff member 1 undertakes the drying performance assessment
- Staff member 2 undertakes the cleaning assessment
- Staff member 3 helps in managing the flow of load items between staff members 1 and 2 and then to storage (or some variation of the above).

Reference Machine Type: Only two of the four Australian test laboratories currently own the Type 2 reference machine as specified in the IEC standard Edition 4 (i.e. Miele G1222 SC). Nevertheless, the drying and cleaning results obtained using the older Type 1 reference machines were found to be reasonably comparable to the G1222 SC. On average the G590 (on the Universal 65 program) produced cleaning score results 9% higher than the G1222 SC and drying score results 3% higher on the IEC reference program. These differences will have implications in relation to regulation of this product type using the IEC test method in Australia/New Zealand in particular in relation to compliance and enforcement programs (noting that AS/NZS currently uses the Gentle 45 program to define mandatory performance levels for cleaning performance only). The apparent differences in the benchmark performance of the two different types of reference machine are of some concern.

Reference Program: The AS/NZS standard currently calls up the Gentle 45 reference program whereas the IEC standard calls up the slightly stronger Universal 65 reference program. Those laboratories with both the old and the new reference machines conducted two of their G590 reference machine runs using the Universal 65 program, in order to benchmark the old and new reference machines, and the other three runs using the Gentle 45 program, in order to provide some comparative data between the new IEC reference and the existing AS/NZS performance benchmark. Comparing the results obtained using the different programs it was found that in one of the labs the average of the raw cleaning scores for the Gentle 45 program was almost identical to that of the Universal 65 program but in the other laboratory the Gentle 45 program returned on average an 11% lower result (this lower result was the more expected outcome). In terms of drying scores across both laboratories, the Gentle 45 program returned results on average 25% lower than the Universal 65 program. This can be explained by the lower final rinse temperature for the Gentle 45 program at about 55°C at the end of the program compared to the Universal 65 program with a final bath temperature of 65°C. Unlike the IEC test method, the AS/NZS method does not use the reference machine to normalise the drying performance results, so the difference in drying score between the Gentle 45 and the IEC/EN reference (Universal 65) are of no concern for the labelling transition in Australia and New Zealand[2]. As noted above, the drying scores on the Type 1 and Type 2 references were generally fairly similar.

[2] If Australia and New Zealand are to adopt the IEC test method then a reference program will need to be agreed (assumed to be Universal 65) and a pass mark in terms of the relative drying performance of the test

Given the significant inherent variation in results for drying performance, it is recommended that any new regulations in Australia and New Zealand should use the drying index to assess drying performance of test machines.

Test room and instrumentation: There are no significantly more stringent requirements in the IEC standard with respect to test room conditions or instrumentation. The most important parameter is energy measurement. The IEC standard specifies only accuracy rather than uncertainty of measurement. A 1% accuracy is specified for energy measurements. Metering requirements for standby power (left on mode and off mode) are referenced to IEC62301 (noting that these requirements are compatible with AS/NZS washer and dishwasher standards, which can be met by all local laboratories).

Test series: AS/NZS defines a single test on a single unit. Multiple tests on the same unit and/or on different samples can be specified as required. IEC require a minimum of five runs in a test series in order to obtain a valid result for a single dishwasher. Filter cleaning is not undertaken between runs in IEC (including the reference machine). If there is little variability then the results of each approach will be comparable. This IEC requirement is considered quite onerous in terms of test burden for laboratories. Five repeat tests on a single unit provide no additional information on variation in the population, which is typically the information of most interest. This issue is discussed in more detail later in this report.

Air drying versus oven drying: Drying of the soil before washing is important as partly dried or wet soils result in more variable wash performance. IEC permits both oven and air drying options. Australia and New Zealand have always used the air drying option as it is considered to be more representative of typical consumer behaviour (consumers do not dry soiled dishes in an oven at 80°C for two hours prior to washing).

Variations to IEC60436 Edition 4 for the round robin

The round robin used the IEC60436 Edition 4 as the test method. Participating test laboratories examined the IEC test procedure closely and highlighted any practical issues in relation to their understanding of the methodology or equipment specification and use. The following items are noted as variations or specified options with respect to the Australian dishwasher round robin:

- Electricity supply was fixed at 230V and 50Hz irrespective of the rated values of the test machines (the rated voltage of each machine included these values)
- IEC60436 soft water option in Clause 5.6.3 was selected for all labs. All labs were within the range <0.85 mmol/litre so no adjustments were required.
- Conditioning of the test machines as specified in clause 5.2 was not undertaken as these were not new machines (noting that these runs have detergent). However, three pre-test runs at rated capacity for all machines (two test machines and the reference machine(s)) were undertaken without detergent, as specified for the IEC round robin.
- Result summaries and raw data were provided by test laboratories.

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machine as compared to that of the reference machine (i.e. the “drying index”) will also need to be determined (this would probably be set to provide equivalent performance to that in the AS/NZS standard).

Testing Specification for the Round Robin

A testing specification document setting out exactly how the IEC test was to be carried out was provided to the test labs prior to the start of testing. A soil preparation training workshop was held with all laboratory technicians prior to the commencement of the round robin to go over the specific differences between the AS/NZS and IEC standards. In addition, briefings and witnessing of tests were conducted for each lab to walk test personnel through the testing process and answer any staff questions. During or after the actual tests, the testing witness visited all facilities to document lab instrumentation, procedures and to answer any further questions generated by the testing. The key elements included in the specification were:

- Products to be tested
- Test specification and any deviations
- Detailed description of the minimum number of test runs required
- Supply and ambient conditions for testing
- Detailed guidance and instructions on soil preparation
- Detailed description of the program to select on each test machine
- Provision of data recording sheets
- Laboratories to provide raw data for independent analysis.

New loads items unique to Edition 4 were purchased from WfK in Germany. These items were then combined with each laboratory's own existing load items so as to make up loads that matched the specifications within IEC 60436 Edition 4.

The laboratories were given common testing specification advice and all the parties were encouraged to share views and experiences so that the round robin testing represented a fair assessment of the IEC methodology. A copy of the testing specification is included as **Appendix A** of this report.

Overview of the Results

Laboratory naming convention for this report

A total of four independent, accredited Australian laboratories participated in this round robin. While there were few anomalies in the results and all labs showed broadly equivalent results, the identity of each laboratory in this report has been concealed. Laboratories are identified as A, B, C and D. Laboratories have been informed of their individual identifiers.

Overall energy, water and cycle time results

A total of 20 test runs were undertaken on each of the 2 test machines used in the round robin (five runs at each of four labs).

The overall energy consumption, water consumption and cycle time results are given for each test machine and laboratory in Table 3 and a summary of the comparative results is shown in Table 4.

Results for run 4 on Machine A in Laboratory A (marked in red) have been eliminated from the calculations of reproducibility and repeatability. This test run activated the feature where additional water was consumed. The particular test machine stores around 5 litres of water from the previous cycle and uses that water for the next cycle. Under some conditions, this stored water appears to be dumped from the machine. However, the trigger for this is not clear as a gap of 20 days did not cause the water to be dumped in one case. Possibly a power outage may cause the water to be dumped (not known whether this occurred). Because of this, all three parameters reported in Table 3 for run number 4 in Laboratory A are affected as follows:

- Water consumption – the unit draws an additional 5 litres from the mains supply.
- Energy Consumption – because the 5 litres drawn from the mains supply is colder (15°C) than that stored in the dishwasher (nominally ambient = 23°C) a small increase in electrical energy is needed to heat that water (noting that most of the additional water drawn in occurs in the middle of the cycle after the first heated operation).
- Cycle time – the unit requires additional time to both drain out the retained water and undertake additional heating of that water as detailed in the point above.

For all of these reasons this particular run, whilst reported in Table 3, has not been used in the assessment of reproducibility or repeatability in Table 4.

Generally, all laboratories gave consistent results in terms of energy consumption and particularly water consumption and time for both test machines. This data shows that the test machines were highly consistent in their operation and behaviour.

The results from these tests indicate that:

- Energy consumption reproducibility averages ± 3% (comparing any single run with any other single run across all laboratories and runs) with the worst result being ± 3.3% for Machine A
- Water consumption reproducibility averages ± 0.8% (comparing any single run with any other single run across all laboratories and runs) with the worst result being ± 1.0% for Machine C
- Cycle time reproducibility averages ± 0.9% (comparing any single run with any other single run across all laboratories and runs) with the worst result being ± 1.1% for Machine C
- Repeatability within a single laboratory for these parameters was similar to reproducibility as detailed above.

Round robin reproducibility in the following tables is calculated as the maximum minus the minimum value for the five test runs divided by two and then divided by the mean.

Table 3: Test results by laboratory – energy, water and time

	Machine A			Machine C		
	Energy consumption (kWh)	Water consumption (l)	Cycle time (min)	Energy consumption (kWh)	Water consumption (l)	Cycle time (min)
Laboratory A						
Run 1	0.918	9.18	140.3	1.373	18.8	122.1
Run 2	0.906	9.17	140.0	1.388	18.8	122.9
Run 3	0.911	9.15	140.0	1.389	18.8	123.0
Run 4	0.950 [1]	14.09 [1]	144.1 [1]	1.393	18.8	122.6
Run 5	0.905	9.18	140.0	1.366	18.8	122.3
Mean	0.918	9.17	140.9	1.382	18.8	122.6
R-R Variation	±1.45%	±0.33%	±0.24%	±1.9%	±0.16%	±0.76%
Laboratory B						
Run 1	0.944	9.19	141.7	1.382	18.9	124.8
Run 2	0.953	9.21	141.8	1.384	18.9	123.5
Run 3	0.957	9.19	141.7	1.390	18.9	123.4
Run 4	0.946	9.18	141.5	1.395	18.9	123.5
Run 5	0.941	9.18	141.6	1.389	18.9	124.7
Mean	0.948	9.19	141.7	1.388	18.9	124.0
R-R Variation	±1.67%	±0.33%	±0.21%	±0.91%	±0.32%	±1.13%
Laboratory C						
Run 1	0.946	9.18	141	1.419	18.8	124.0
Run 2	0.940	9.19	141	1.412	18.8	124.0
Run 3	0.959	9.19	142	1.441	18.7	124.8
Run 4	0.945	9.18	141	1.415	18.8	124.8
Run 5	0.935	9.20	141	1.386	19.0	124.0
Mean	0.945	9.19	141.2	1.415	18.8	124.3
R-R Variation	±2.5%	±0.22%	±0.71%	±3.87%	±1.49%	±0.6%
Laboratory D						
Run 1	0.903	9.1	140	See Note 2	See Note 2	See Note 2
Run 2	0.901	9.1	140	See Note 2	See Note 2	See Note 2
Run 3	0.922	9.1	141	See Note 2	See Note 2	See Note 2
Run 4	0.901	9.1	140	1.373	18.67	124.0
Run 5	0.897	9.1	140	1.375	18.67	123.0
Mean	0.905	9.1	140.2	1.374	18.67	123.5
R-R Variation	±2.76%	±0%	±0.71%	±0.15%	±0%	±0.81%
Closing of the Ring Tests (Laboratory D)						
Run 1	0.889	9.2	140	1.342	18.6	121.0
Run 2	0.892	9.1	140	1.345	18.6	121.0
Run 3	0.88	9.2	139	1.341	18.5	122.0
Mean	0.887	9.17	139.7	1.343	18.6	121.3
R-R Variation	±0.68%	±0.55%	±0.36%	±0.15%	±0.27%	±0.41%

Note 1: The result for Run 4 on Machine A in Laboratory A (marked in red) has been eliminated from the calculations of reproducibility and repeatability – see earlier discussion on this subject.
Note 2: Following a malfunction with Machine B (later excluded from this round robin) only limited runs could be undertaken on the replacement Machine C.

Table 4: Test results summary – energy, water and time

	Machine A			Machine C		
	Energy consumption (kWh)	Water consumption (l)	Cycle time (min)	Energy consumption (kWh)	Water consumption (l)	Cycle time (min)
All Labs						
Mean	0.929	9.16	141.0	1.39	18.81	123.6
Reproducibility (5 run average)	±2.3%	±0.5%	±0.5%	±1.5%	±0.6%	±0.7%
Reproducibility (any one run)	±3.3%	±0.6%	±0.7%	±2.7%	±1%	±1.1%
Both Machines Reproducibility **(any one run) >>>>>>**				±3%	±0.8%	±0.9%

Given that the water and time measurements were very close across all laboratories, the larger variation in energy is somewhat surprising. Two laboratories were about 35 Wh higher than the other two laboratories for Machine A and one laboratory was 35 Wh higher for Machine C. While this is only 3.3% for Machine A and 2.7% for Machine C, it does suggest that there may be some small systematic error creeping into the measurements. All laboratories used similar high quality energy measurement equipment, so it is unlikely to be a calibration issue. Review of data found no specific issues with respect to laboratory air temperatures, cold water supply temperatures or bath temperatures. Later investigations show that cold water corrections and initial ambient conditions explain part of these differences, but that there may be some minor calibration or configuration issues with energy measurements.

Energy, water and time results for each of the reference machines is shown in Table 5. In this table results for the G590 machine are reported on the left hand side of the table and results for the G1222SC (only used in laboratories A and D) are reported on the right hand side of the table. The results shown in red were from runs that used the Gentle 45 Wash program. All other results (in black) are based on the Universal 65 program. For those laboratories with results in red, only the results in black (i.e. those comparable to other laboratories) are used in the calculation of the mean and the round robin variation values.

All of these results suggest that the IEC test method would be suitable for regulatory purposes within the Australian and New Zealand context for energy and water consumption. Furthermore, it is apparent that in respect of these three parameters, the IEC requirement to undertake a minimum of five repeat tests in order to obtain a valid result is unnecessarily onerous. The testing of products with on board water storage does raise some interesting issues for regulators in terms of a valid declaration of performance. It is important that the IEC test method acknowledge such features and measure performance with the feature both activated and deactivated. Regulators will then need to decide how they deal with these feature in the context of energy labelling.

Table 5: Reference Machine Results by laboratory – energy, water and time

	G590 Reference			G 1222SC Reference		
	Energy consumption (kWh)	Water consumption (l)	Cycle time (min)	Energy consumption (kWh)	Water consumption (l)	Cycle time (min)
Laboratory A						
Run 1	1.66	26.6	88.8	1.32	14.7	98.0
Run 2	1.68	26.6	89.3	1.34	14.7	98.5
Run 3	1.20[1]	26.0	78.8	1.33	14.6	98.5
Run 4	1.21	25.9	79.2	1.34	14.6	98.3
Run 5	1.19	26.0	78.9	1.31	14.7	97.6
Mean (R1 & R2)	1.67	26.6	89.1	1.33	14.6	98.2
R-R Variation	±0.66%	±0%	±0..28%	±2.07%	±0.07%	±0.97%
Laboratory B						
Run 1	1.77	25.9	90.8			
Run 2	1.77	25.7	90.8			
Run 3	1.79	26.1	91.1			
Run 4	1.78	25.9	91.0			
Run 5	1.77	25.9	91.1			
Mean	1.78	25.9	91.0			
R-R Variation	±1.21%	±1.62%	±0.33%			
Laboratory C						
Run 1	1.76	26.5	93.0			
Run 2	1.76	26.7	90.8			
Run 3	1.73	26.6	90.8			
Run 4	1.76	26.7	91.0			
Run 5	1.72	26.8	90.0			
Mean	1.75	26.7	91.1			
R-R Variation	±2.36%	±1.13%	±3.29%			
Laboratory D						
Run 1	1.74	27.4	91.0	1.25	14.4	96.0
Run 2	1.74	27.2	91.0	1.25	14.4	96.0
Run 3	1.16[1]	27.4	79.0	1.27	14.4	97.0
Run 4	1.15	27.4	79.0	1.26	14.4	96.0
Run 5	1.15	27.4	78.0	1.26	14.4	96.0
Mean (R1 & R2)	1.74	27.3	91.0	1.26	14.4	96.2
R-R Variation	±0.06%	±0.29%	±0%	±1.27%	±0%	±1.04%
Closing of the Ring Tests (Laboratory D)						
Run 1	1.70	27.4	90.0	1.25	14.5	96.0
Run 2	1.69	27.2	90.0	1.23	14.5	96.0
Run 3	1.69	27.3	90.0	1.36[2]	14.5	96.0
Mean	1.69	27.3	90.0	1.28	14.5	96.0
R-R Variation	±0.3%	±0.37%	±0%	±5.07%	±0%	±0%

Note 1: The results above shown in red were from runs that used the Gentle 45 program. All other results (in black) are based on the Universal 65 program. For those laboratories with results in red, only the results in black (i.e. those comparable to other laboratories) are used in the calculation of the mean and the round robin variation. Note 2: The higher energy value for the G1222 SC run on the closing tests has been checked. Temperatures and water volumes were the same, so the cause of the difference is unclear. It may relate to a transcription error (no log data was available for this particular run).

Cleaning Performance

REPEATABILITY – RAW SCORES

An assessment was undertaken of the run to run variability in terms of the raw cleaning scores for each laboratory and each machine (see Table 6). Whilst each assessor in each laboratory returned markedly different raw scores to each other (raw scores being later corrected against the reference machine score), the run to run variability within each laboratory was reasonably consistent. On average the run to run variation was found to be ±2.5% to ±3%. The worst result was just under ±6%[3] and the best result just under ±2% (noting that the result for Machine C in Laboratory D has been excluded as only two valid runs were completed on that machine in this laboratory).

Table 6: Cleaning Performance – repeatability of the sum of all scores (raw)

Machine A - Cleaning-Sum of all Scores						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Laboratory A	463	467	492	458	472	±3.6%
Laboratory B	610	643	626	610	631	±2.6%
Laboratory B	662	657	640	646	649	±1.7%
Laboratory D	552	546	586	569	577	±3.5%
Lab D (Return)	517	528	507			±2.0%
					Average Variation >	**±2.7%**
Machine C - Cleaning-Sum of all Scores						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Laboratory A	530	494	501	477	471	±5.9%
Laboratory B	632	654	636	639	648	±1.7%
Laboratory B	639	661	658	641	644	±1.7%
Laboratory D	See Note 1	See Note 1	See Note 1	578	587	±0.8%
Lab D (Return)	548	531	523			±2.3%
					Average Variation >	**±2.5%**

Note 1: Following a malfunction with Machine B (later excluded from this round robin) only limited runs were able to be undertaken at this laboratory on the replacement Machine C. During the closing of the ring tests however, Laboratory D did conduct three additional runs on Machine C with cleaning scores as noted above.

The original argument made in IEC to justify a minimum of five test runs was based on machines where filters do not automatically clear themselves of excess soil between runs. In these circumstances machines will degrade in performance over time and the variation of cleaning performance will increase (the cleaning score will degrade with more runs as the filter clogs up). The standard specifies that where W_C is greater than 0.073 after five runs, then up to three additional runs are to be performed without filter cleaning. If after eight runs the value of W_C is still greater than 0.073 then the filter is declared as a manually cleaned filter and five new test runs are to be conducted with filter cleaning between runs (that is a total of 13 runs). If W_C is less than or equal to 0.073 after five or eight runs then the filter is classified as automatic or self-cleaning.

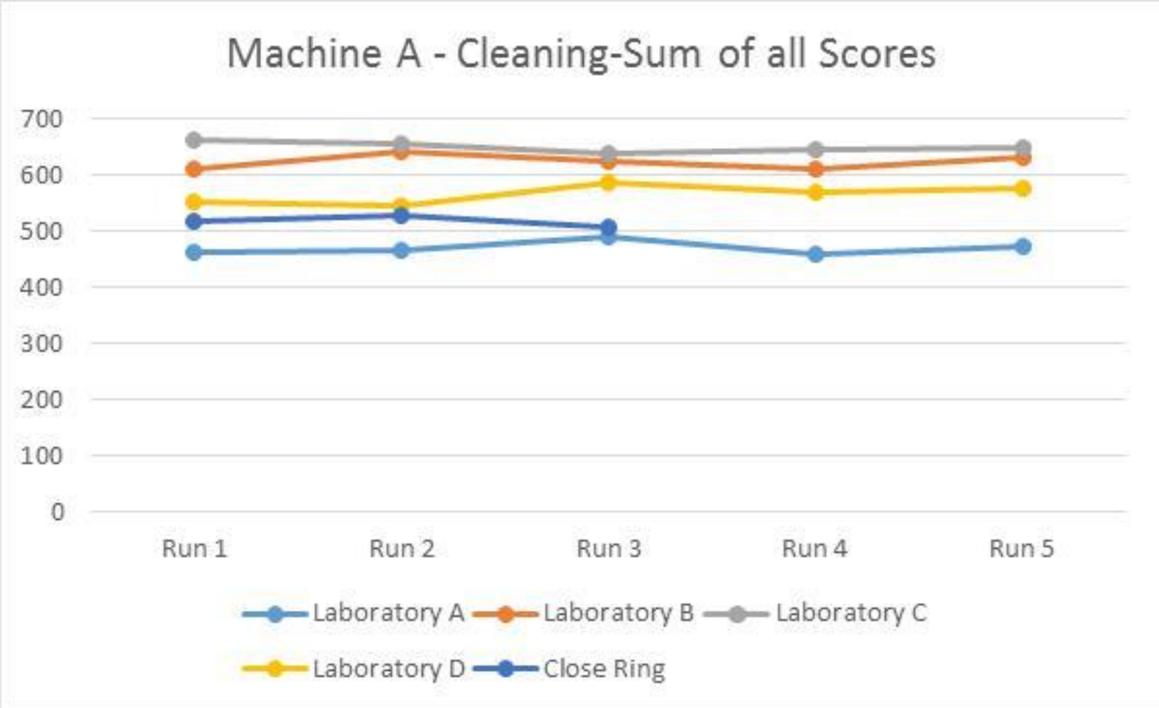
[3] It is notable that the outlier that resulted in this relatively high level of variability was on the first run, which may have been driven by the laboratory's inexperience with the IEC method. If this outlier is excluded then the variability drops to ± 3%.

The problem with this approach is that the assessment of cleaning performance (how clean does it wash the dishes?) is being mixed up with a separate performance assessment i.e. whether or not the filter is automatic (self-cleaning) or manual, which the supplier is supposed to declare. Most dishwashers (including the round robin machines) have automatic filters that only need to be cleaned by the user periodically (typically after 30 to 50 runs). So the current IEC test method has a routine assessment of the filter performance merged with the cleaning performance assessment. This is very resource intensive and probably a waste of valuable testing time and effort. Much better information would be obtained on the production variability of a model (which is of more interest than the precise performance of a single machine) if multiple units were tested once each. A much more workable approach would be to require a declaration of the filter type by the manufacturer as part of the standard (this is currently required in any case). This claim could be assessed by testing a single machine up to 8 times (as currently required) to see whether W_C is greater than 0.073 or not during a verification test. In the Australian and New Zealand context, a manufacturer may be required to declare whether their filter is automatic or manual during registration. This is certainly a parameter that could then be covered by check tests to verify that the claim is valid. Whether or not a supplier would be required to supply documentary evidence that the filter is automatic, where claimed, in the registration would need to be considered by regulators. Where a cleaning test is defined for a single run, there is always the option for multiple tests, depending on specific requirements and the required accuracy of results.

There is no doubt the dishwasher cleaning performance is a parameter where there is naturally some run to run variation in the measurement. Data from the round robin shows that, while there is some internal variability in cleaning scores from run to run, these are generally within a defined band – see Figure 1. Some variability in cleaning scores is to be expected as the soils used are natural materials, they are prepared by people, applied by people and are visually assessed by people. So there are a lot of factors that can impact on the absolute score and the variation in scores from run to run. Undertaking multiple runs on a single machine is of some value if you need to be highly confident of the result on a specific machine.

From a regulatory perspective, it is much more valuable to have slightly less accurate information on the performance variation across the population of a specific model rather than have highly accurate information on a single unit. If five different units of the one model are tested once, then the repeatability (or run to run variation) will smooth itself out across these units in any case if the procedures in the standard are followed. So for the same testing expenditure, you could achieve considerably better information on the population by testing more units with just one run each, which more useful for public information and consumer protection.

Figure 1: Cleaning Performance – run to run variation in sum of all scores



CLEANING PERFORMANCE INDEX – Repeatability and Reproducibility

The cleaning performance index is the ratio of the cleaning score obtained on the test machine compared to the cleaning score obtained on the reference machine run in parallel with the test machine. Because all of the test and reference machines are 12 place settings, no adjustments for varying numbers of place settings are required in the cleaning performance index calculation for the round robin. Normally the cleaning index normalises the results for the number of place settings on the test machine and the reference machine.

Because the cleaning performance index is a comparative result of the test machine compared to the reference machine, it provides a fair basis for comparing cleaning performance between laboratories. However, a valid comparison across laboratories can only be obtained where reference machines in different labs actually have the same performance. Reference machines are designed to provide a consistent cleaning performance benchmark for assessing test machines. However, it is usually difficult to assess and compare them in parallel across different laboratories.

Whilst all laboratories owned and operated the G590 reference machine during each test, only two of the laboratories (A and D) also owned and operated the G1222 SC reference machines during the tests. For the round robin, the new reference machine was selected as the official reference machine for Laboratory A and D and the G590 was selected as the official reference for Laboratory B and C.

Whilst those laboratories with only the G590 reference machines (B and C) operated them exclusively on the Universal 65 program, those laboratories with both old and new reference machines (A and D) operated their G590 machines on the Universal 65 program for the first two runs, the remaining three runs on the G590s were operated on the Gentle 45 program, effectively as an additional test machine against the Type 2 reference. This was specified on the basis that the Universal 65 program on the old and new reference should be comparable and operating the old reference on the Gentle 45 program would provide very valuable cleaning performance benchmark data that will assist in setting equivalent cleaning performance requirements in AS/NZS for energy labelling under the IEC test method. On review of the data, it would appear that there is some absolute difference in cleaning performance for the old and new reference.

Table 7 details the run to run variability in the cleaning performance index for comparable runs using only the G590 as the reference where runs on the G590 on the Universal 65 were available in each of the four test laboratories. The results indicate a relatively high level of repeatability averaging ±2.1% for Machine A and ±2.4% for Machine C, with the worst result in any one laboratory being ±4.7%.

Table 7: Cleaning Performance – repeatability of the cleaning performance index using only Type 1 reference

Machine A – Cleaning Index						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Laboratory A	0.969	1.006	See Note 1	See Note 1	See Note 1	±1.9%
Laboratory B	0.985	1.017	1.015	0.971	1.014	±2.3%
Laboratory C	1.054	1.051	1.026	1.061	1.055	±1.7%
Laboratory D	1.078	1.056	See Note 1	See Note 1	See Note 1	±1.0%
Lab D (Return)	1.006	0.991	0.941			±3.3%
					Average Variation >	**±2.1%**
Machine C – Cleaning Index						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Laboratory A	1.109	1.065				±2.0%
Laboratory B	1.021	1.035	1.031	1.018	1.042	±1.2%
Laboratory C	1.018	1.049	1.054	1.053	1.047	±1.8%
Laboratory D	See Note 2	See Note 2	See Note 1&2	See Note 1	See Note 1	
Lab D (Return)	1.066	0.996	0.970			±4.7%
					Average Variation >	**±2.4%**

Note 1: Runs 3, 4 and 5 at Laboratories A and D were undertaken using the Gentle 45 program on the G590 reference machine and are therefore not comparable to the other results reported in the above table that are all based on the use of the G590 reference machine operating the Universal 65 program.
Note 2: Following a malfunction with Machine B (later excluded from this round robin) only limited runs were able to be undertaken at this laboratory on the replacement Machine C. During the closing of the ring tests however, Laboratory D did conduct three additional runs on Machine C with cleaning index scores as shown above.

Table 8 reports the run to run variability in the cleaning performance index for comparable runs using the G1222SC as the reference in laboratories that have this machine (A and D) and the G590 in those laboratories that do not (Laboratories B and C). In all cases the machines were operated using the Universal 65 program (IEC/EN reference).

Table 8: Cleaning Performance – repeatability of the cleaning performance index using Type 1 or Type 2 reference

Machine A – Cleaning Index						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Lab A (G1222)	1.138[2]	1.017	1.098	1.063	1.019	±5.6%[2]
Lab B (G590)	0.985	1.017	1.015	0.971	1.014	±2.3%
Lab C (G590)	1.054	1.051	1.026	1.061	1.055	±1.7%
Lab D (G1222)	1.165	1.138	1.069	1.114	1.003	±7.3%
Lab D (Return)	1.057	1.046	1.037			±0.98%
					Average Variation >	**±3.6%**[2]
Machine C – Cleaning Index						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Lab A (G1222)	1.302[2]	1.076	1.118	1.107	1.017	±12.7%[2]
Lab B (G590)	1.021	1.035	1.031	1.018	1.042	±1.2%
Lab C (G590)	1.018	1.049	1.054	1.053	1.047	±1.8%
Lab D (G1222)	See Note 1	See Note 1	See Note 1	1.131	1.021	±5.1%
Lab D (Return)	1.121	1.051	1.07			±3.2%
					Average Variation >	**±4.8%**[2]

Note 1: Following a malfunction with Machine B (later excluded from this round robin) only limited runs were able to be undertaken at this laboratory on the replacement Machine C.
Note 2: Run 1 on the Type 2 reference at Laboratory A appeared to give a different value for cleaning performance when compared to the Type 1 reference and the two test machines run at the same time and when compared to subsequent runs. While the results for Machine A and the G590 were as expected, for run 1, the results for machine C were much higher than subsequent runs and the results for the G1222SC were much lower than subsequent runs. This was the first IEC test performed and there may have been some operational issues. If run 1 from Laboratory A is excluded from the calculations of reproducibility on the basis that these are significantly different to the expected values, the calculated average variation across all laboratories are achieved:

- Laboratory A – Machine A repeatability ±3.9%
- Laboratory A – Machine C repeatability ±4.7%
- Machine A – Average Variation ±3.8%
- Machine C – Average Variation ±3.2%

In terms of reproducibility between laboratories, the results from Table 7 indicate a reproducibility as detailed in Table 9 when only the G590 is used as a reference. Using the averaged results for each laboratory (i.e. the average of up to five runs) the average reproducibility was found to be ±3.3%. Alternatively, comparing any single run with any other single run across all laboratories and runs the average reproducibility was found to be ±4.9%. When the Type 1 or Type 2 is used as a reference (see Table 8), the averaged results for each laboratory (i.e. the average of up to 5 runs) the average reproducibility was found to be ±4.5% (or ±3.5% if the Lab A run 1 outlier is excluded). Alternatively, comparing any single run with any other single run across all laboratories and runs the average reproducibility was found to be ±11.3% (or ±7.3% if the Lab A run 1 outlier is excluded). The increased variation in reproducibility when using either the Type 1 or Type 2 reference suggests that there are some differences in the benchmark cleaning performance of Type 1 and Type 2 reference machines. This is discussed in more detail in the next section.

As expected, comparing averaged results provided a better level of reproducibility, as opposed to comparing any single run with any other single run across all laboratories and all runs but the difference is relatively modest. Comparing any single run with any other single run across all laboratories and all runs is akin to a comparison based on a single test run only undertaken in each laboratory as distinct from undertaking say five runs as mandated in the IEC standard.

Table 9: Cleaning Performance – reproducibility of the cleaning performance index

Test Machine	Comparing the 4 laboratories averaged results over all of their runs	Comparing any single run with any other single run across all laboratories and all runs
Machine A Type 1 reference	±3.9%	±5.3%
Machine C Type 1 reference	±2.7%	±4.4%
Average Type 1 reference	±3.3%	±4.9%
Machine A Type 1/2 reference	±4.6	±9.2
Machine C Type 1/2 reference	±4.4	±13.4
Average Type 1/2 reference	±4.5	±11.3
Results obtained when the outlier (Run 1 Lab A) is excluded – Type 1/2 reference		
Machine A Type 1/2 reference	4.6%	9.2%
Machine C Type 1/2 reference	2.4%	5.4%
Average Type 1/2 reference	3.5%	7.3%

This data suggests that for the Australian laboratories at least, using different reference machines appears to generate larger variations in reproducibility. This appears to be driven by different performance benchmarks for these machines, at least as they were configured for the round robin.

Comparing the two reference machines cleaning performance when operated on the same program (Universal 65) – see Table 10, it is apparent that the G590 on average attains an approximate 8% higher score than the G1222. In the case of Laboratory D, this difference is reasonably consistent varying between 5% and 10%. In the case of Laboratory A the results are more variable but as only two runs at laboratory A were comparable it is difficult to draw a strong conclusion in relation to this laboratory.

Table 10: Comparison of Reference Machines (Raw Cleaning Scores) – Universal 65 Program

Laboratory A – Comparison of Cleaning Scores Between Reference Machines (Universal 65)						
Machine	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Mean**
G590	478	464				471
G1222	407	459				433
G590/G1222	1.17	1.01				1.09
Laboratory D – Comparison of Cleaning Scores Between Reference Machines (Universal 65)						
Machine	**Run 1**	**Run 2**	**Run 6**	**Run 7**	**Run 8**	**Mean**
G590	512	517	514	533	539	523
G1222	474	480	489	505	489	487.4
G590/G1222	1.08	1.08	1.05	1.06	1.10	1.07

Note 1: Runs 3, 4 and 5 at Laboratories A and D were undertaken using the Gentle 45 setting on the G590 reference machine and are therefore not comparable to the G1222 results that used the Universal 65 program). In the case of laboratory D, runs 3, 4 and 5 refer to the closing of the ring tests.

Drying Performance

REPEATABILITY – RAW SCORES

An assessment was undertaken of the run to run variability in terms of the raw drying scores for each laboratory and each machine (see Table 11). Whilst each assessor in each laboratory returned marginally different raw scores to each other (this difference being later corrected against the reference machine score), the run to run variability within the one laboratory was reasonably consistent. On average the run to run variation was found to be ±3% to ±5%. The worst result was just under ±6% and the best result just under ±2.5% (noting that the result for Machine C in Laboratory D has been excluded as only 2 valid runs were completed on that machine in this laboratory).

The relatively low variability between the raw drying scores obtained by each laboratory supports the concept applied in the current AS/NZS standard that an absolute measurement in relation to drying performance (as distinct from a relative measurement against a reference machine) produces results with a reasonable level of reproducibility (± 5% to ±8% based on the results reported in Table 11). Nevertheless as will be seen in the following section on the drying index results, by using a relative measure (i.e. with the reference machine as a performance benchmark) a marginally better level of reproducibility can be achieved.

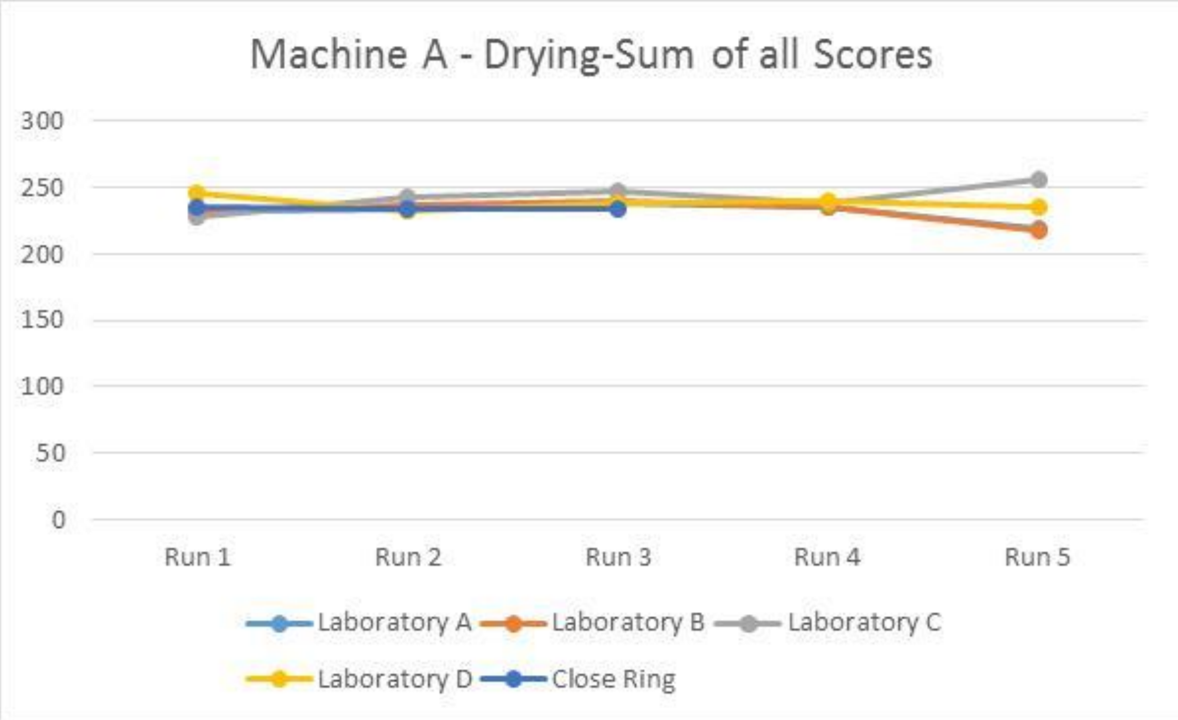
Table 11: Drying Performance – repeatability of the sum of all scores (raw)

Machine A - Drying-Sum of all Scores						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Laboratory A	233	234	239	235	219	±4.3%
Laboratory B	233	237	240	236	218	±4.7%
Laboratory C	228	243	247	238	256	±5.8%
Laboratory D	245	232	239	240	235	±2.7%
Lab D (Return)	236	234	234			±0.4%
					Average Variation >	**±3.6%**
Machine C - Drying-Sum of all Scores						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Laboratory A	223	233	227	231	236	±2.8%
Laboratory B	235	219	241	240	236	±4.7%
Laboratory C	239	238	250	243	239	±2.5%
Laboratory D	See note 1	See note 1	See note 1	230	229	±0.2%
Lab D (Return)	229	237	237			±1.7%
					Average Variation >	**±2.4%**

Note 1: Following a malfunction with Machine B (later excluded from this round robin) only limited runs were able to be undertaken at this laboratory on the replacement Machine C.

The use of a minimum of five test runs in the IEC is to take account of variations in repeatability for this test. The evidence from these tests suggests that raw drying performance is reasonably stable – see Figure 2.

Figure 2: Drying Performance – run to run variation in sum of all scores (raw)



DRYING PERFORMANCE INDEX – Repeatability and Reproducibility

The drying performance index as defined in the IEC standard is the ratio of the drying score obtained on the test machine to the drying score obtained on the reference machine when run in parallel. Because all of the test and reference machines are 12 place settings, no adjustments for varying numbers of place settings are required in the drying performance index calculation for the round robin. Normally the drying index normalises the results for the number of place settings on the test machine and the reference machine.

As with the cleaning performance index, because the drying performance index is a comparative result compared to the reference machine, the assumption is that the old and new reference machines have the same performance when operated on the same program. Whilst those laboratories with only the G590 reference machines (B and C) operated them exclusively on the Universal 65 program, those laboratories with both reference machines (A and D) operated their G590 machines on the Universal 65 program only for the first two runs, the remaining three runs on the G590s were operated on the Gentle 45 program. Laboratories A and D used the G1222 SC as the primary reference.

Table 12 details the run to run variability in the drying performance index for comparable runs using only the G590 as the reference in each of the four test laboratories. The results indicate a relatively high level of repeatability averaging ±2.6% for Machine A and ±3.4% for Machine C with the worst result in any one laboratory ±5.1%.

Table 12: Drying Performance – repeatability of the drying performance index using only Type 1 reference

Machine A – Drying Index						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Laboratory A	0.996	1.026	See Note 1	See Note 1	See Note 1	±1.5%
Laboratory B	1.045	1.026	1.008	0.975	0.944	±5.1%
Laboratory C	1.004	1.025	0.984	0.988	1.076	±4.5%
Laboratory D	0.988	0.971	See Note 1	See Note 1	See Note 1	±0.9%
Lab D (Return)	0.996	0.979	0.971			±1.3%
					Average Variation >	**±2.6%**
Machine C – Drying Index						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Laboratory A	0.953	1.022				±3.5%
Laboratory B	1.054	0.948	1.013	0.992	1.022	±5.3%
Laboratory C	1.053	1.004	0.984	1.021	1.004	±3.4%
Laboratory D	See Note 2	See Note 2	See Note 1&2	See Note 1	See Note 1	
Lab D (Return)	0.966	0.992	0.983			±1.3%
					Average Variation >	**±3.4%**

Note 1: Runs 3, 4 and 5 at Laboratories A and D were undertaken using the Gentle 45 setting on the G590 reference machine and are therefore not comparable to the other results reported in the above table that are all based on the use of the G590 reference machine operating the Universal 65 program.
Note 2: Following a malfunction with Machine B (later excluded from this round robin) only limited runs were able to be undertaken at this laboratory on the replacement Machine C.

Table 13 reports the run to run variability in the cleaning performance index for comparable runs using the G1222SC as the reference in laboratories that have this machine (Lab A and Lab D) and the G590 in those laboratories that do not (Lab B and C). In all cases the machines were operated using the Universal 65 program.

As can be seen by comparing the repeatability results from Table 13 to Table 12, whether a common reference machine is used or either the Type 1 or Type 2 machine, the result is similar in terms of the run to run variability of the drying index score.

Also of note is the consistency between the initial runs undertaken in Laboratory D on Machine A and the “closing of the ring” runs undertaken at the end of the round robin in Laboratory D on the same machine. These results suggest that in terms of drying performance this machine performed consistently throughout the round robin process (a similar assessment was not possible in respect of machine C because in the first round of testing only runs on the Gentle 45 program were undertaken on machine C in laboratory D due to test unit failure).

Table 13: Drying Performance – repeatability of the drying performance index using Type 1 or Type 2 reference

Machine A – Drying Index						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Variation**
Lab A (G1222)	0.991	1.049	1.030	1.040	0.995	±2.8%
Lab B (G590)	1.045	1.026	1.008	0.975	0.944	±5.1%
Lab C (G590)	1.004	1.025	0.984	0.988	1.076	±4.5%
Lab D (G1222)	1.043	1.009	0.992	1.067	1.009	±3.7%
Lab B (Return)	0.992	0.959	0.992			±1.7%
					Average Variation >	±3.5
Machine C – Drying Index						
Laboratory	**Run 1**	**Run 2**	**Run 3**	**Run4**	**Run 5**	**Variation**
Lab A (G1222)	0.949	1.045	0.978	1.022	1.073	±6.1%
Lab B (G590)	1.054	0.948	1.013	0.992	1.022	±5.3%
Lab C (G590)	1.053	1.004	0.984	1.021	1.004	±3.4%
Lab D (G1222)	See Note 1	See Note 1	See Note 1	1.022	0.983	±2.0%
Lab B (Return)	0.962	0.971	1.004			±2.2%
					Average Variation >	±3.8%

Note 1: Following a malfunction with Machine B (later excluded from this round robin) only limited runs were able to be undertaken at this laboratory on the replacement Machine C.

In terms of reproducibility between laboratories the results from Table 12 indicate a reproducibility as detailed in Table 14. Using the averaged results for each laboratory (i.e. the average of up to five runs) the average reproducibility was found to be ±1.7% when using only the Type 1 as the reference (G590). Alternatively, comparing any single run with any other single run across all laboratories and all runs, the average reproducibility was found to be ±5.9% when using only the Type 1 as the reference. When the Type 1 or Type 2 is used as a reference, the averaged results for each laboratory (i.e. the average of up to 5 runs) the average reproducibility was found to be ±1.9%. Alternatively, comparing any single run with any other single run across all laboratories and runs the average reproducibility was found to be ±6.4%. This suggests that the drying performance of the Type 1 and Type 2 reference machines is fairly comparable. This is discussed in more detail in the next section.

As expected, comparing averaged results provided a better level of reproducibility as opposed to comparing any single run with any other single run across all laboratories and all runs. Comparing any single run with any other single run across all laboratories and all runs is akin to a comparison based on a single test run only undertaken in each laboratory as distinct from undertaking say five runs as mandated in the IEC standard. The single run approach yields a reproducibility of approximately ±6% which might be considered adequate for regulatory purposes. While the test machines and the references machines are very consistent, the data illustrates that the cleaning performance is generally slightly more variable than the drying performance.

It is also apparent that the use of a reference machine to determine the drying performance of a test machine does marginally improve the reproducibility of the test results. Using averages over five runs, the use of a reference machine improves the reproducibility from ±2.4% down to ±1.7% (G590 only) or ±1.9% (G590 or G1222). Comparing any run with any other run the use of a reference machine improves the reproducibility from ±7.3% down to ±5.9% (G590 only) or ±6.4% (G590 or G1222).

Table 14: Drying Performance – reproducibility of the drying performance index

Test Machine	Comparing the 4 laboratories averaged results over each of their runs	Comparing any single run with any other single run across all laboratories and all runs
Machine A Type 1 reference	±1.8%	±6.6%
Machine C Type 1 reference	±1.6%	±5.3%
Average Type 1 reference	±1.7%	±5.9%
Machine A Type 1/2 reference	±2.1%	±6.5%
Machine C Type 1/2 reference	±1.7%	±6.2%
Average Type 1/2 reference	±1.9%	±6.4%

Comparing the two reference machines drying performance when operated on the same program (Universal 65) as set out in Table 15, it is apparent that the G590 on average attains an approximate 1% to 2% higher score than the G1222. In the case of Laboratory A this difference is reasonably consistent, varying between 0% and 2%. In the case of Laboratory D, the results are more variable but on average are very similar to Laboratory A.

Table 15: Comparison of Reference Machines (Drying Scores) – Universal 65 Program

Laboratory A – Comparison of Drying Scores Between Reference Machines (Universal 65)						
Machine	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Mean**
G590	234	228				231
G1222	235	223				229
G590/G1222	1.00	1.02				1.01
Laboratory D – Comparison of Drying Scores Between Reference Machines (Universal 65)						
Machine	**Run 1**	**Run 2**	**Run 6**	**Run 7**	**Run 8**	**Mean**
G590	248	239	237	239	241	240.8
G1222	235	230	238	244	236	236.6
G590/G1222	1.06	1.04	1.00	0.98	1.02	1.02

Note 1: Runs 3, 4 and 5 at Laboratories A and D were undertaken using the Gentle 45 setting on the G590 reference machine and are therefore not comparable to the G1222 results that used the Universal 65 program). In the case of laboratory D, runs 3, 4 and 5 refer to the closing of the ring tests

Reference Machines – Comparison

COMPARING MACHINE TYPES

As noted in previous sections, two different types of reference machines were available in two of the participating test laboratories. These were both operated in parallel with the test machines. This meant that cleaning and drying results from the two different types of machine could be compared in circumstances where both machines (G590 and G1222 SC) were being operated on the same program (i.e. Runs 1 and 2) as well as the three repeat runs at Laboratory D.

From the analysis in the previous section of this report, the following observations were made when operating on the Universal 65 program:

- The G590 produces cleaning performance raw score results on average approximately 8% better than the G1222 (noting some run to run variability) so this has a higher cleaning index when benchmarked to the G1222 reference.
- The G590 produces drying performance raw score results on average approximately 2% better than the G1222 (noting some run to run variability) so this has a slightly higher drying index when benchmarked to the G1222 reference.

These results suggest that, when used to assess the cleaning and drying performance of a test machine, using the older G590 reference machine will produce slightly more conservative (lower) cleaning performance index and drying performance index compared to tests conducted using the G1222 SC if the results in Lab A and Lab D are representative of all references. This is an issue that will be raised with Miele, as presumably this has been raised by other laboratories if the issue is wide spread. It may be that calibration procedures and other adjustments may be able to ameliorate this difference in performance.

Assuming that some underlying difference in cleaning performance between the G590 and the G1222 SC remain after investigations, then some regulatory adjustments may need to be made. If compliance testing were to only ever be undertaken using the newer G1222 SC reference machine, then those checktested products that relied on registration tests undertaken using the older G590 reference machine would not be unduly disadvantaged. The reverse situation (checktest using G590 of a product that relied on a test using the G1222SC) would be to the disadvantage of the test machine (effectively marking down the cleaning and drying performance scores).

COMPARING REFERENCE MACHINE PROGRAMS

As noted in previous sections, for those laboratories that used two different types of reference machines in parallel, the first two runs on the G590 were undertaken using the Universal 65 program and the remaining three runs on the G590 were undertaken using the Gentle 45 program (all runs on the G1222SC were undertaken on the Universal 65 program). The objective of this was to provide some relative benchmarking of the Gentle 45 program (currently used to define minimum cleaning performance in AS/NZS) to the IEC/EN reference program.

Table 16 compares the cleaning performance of the two types of reference programs operating on different reference machines in the same laboratory. The results compare the average of the three runs on the G590 on Gentle 45 with three runs on the G1222SC on the Universal 65 (IEC/EN reference) when run in parallel. The results show that the Gentle 45 program is about 4% weaker than the IEC/EN reference program for cleaning.

Table 17 compares the drying performance of the two types of reference programs operating on different reference machines in the same laboratory. The results compare the average of the three runs on the G590 on Gentle 45 with three runs on the G1222SC on the Universal 65 (IEC/EN reference) when run in parallel. The results show that the Gentle 45 program is about 25% weaker than the IEC/EN reference program. This is expected, as the final rinse temperature on the IEC/EN reference is 68°C compared to the final rinse temperature of 55°C on the Gentle 45 program.

Table 16: Reference program comparative cleaning index - Gentle 45 and Universal 65 program

Laboratory A – Comparison of Cleaning Scores Between Reference Machines – Gentle 45-IEC/EN ref						
Machine	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Mean**
G590 G45			403	420	435	**419**
G1222 IEC ref			448	431	463	**447**
G590/G1222			0.90	0.97	0.94	**0.94**
Laboratory D – Comparison of Cleaning Scores Between Reference Machines – Gentle 45-IEC/EN ref						
Machine	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Mean**
G590 G45			489	553	538	**527**
G1222 IEC ref			548	511	575	**545**
G590/G1222			0.89	1.08	0.94	**0.97**

Notes: All results compared to the G1222 SC as the reference

Table 17: Reference program comparative drying index - Gentle 45 and Universal 65 program

Laboratory A – Comparison of Drying Scores Between Reference Machines – Gentle 45-IEC/EN ref						
Machine	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Mean**
G590 G45			183	170	183	**179**
G1222 IEC ref			232	226	220	**226**
G590/G1222			0.79	0.75	0.83	**0.79**
Laboratory D – Comparison of Drying Scores Between Reference Machines – Gentle 45-IEC/EN ref						
Machine	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Mean**
G590 G45			171	166	182	**173**
G1222 IEC ref			241	225	233	**233**
G590/G1222			0.71	0.74	0.78	**0.74**

Notes: All results compared to the G1222 SC as the reference

There had been some concern in the past that use of the Universal 65 program (as mandated in the IEC standard) might reduce the sensitivity of the test particularly in relation to the cleaning performance assessment because a stronger wash means that most items are fairly clean, so this may not differentiate the cleaning performance of machines with lower performance. The limited results above suggest that, at least in the case of the cleaning performance test, this is unlikely to be the case because the cleaning performance of Gentle 45 is broadly comparable to Universal 65 on the G590. This finding suggests that the adoption of the Universal 65 program as the reference program to be used in AS/NZS, if the IEC standard is to be adopted, should not cause any major issues. Use of the Universal 65 program provides a distinct advantage in terms of harmonisation with the test method used in the EU and other regions and will help to facilitate the acceptance of European test reports by Australian and New Zealand regulators (and vice versa).

Standby power

As part of the round robin, three different low power modes were measured as defined in IEC60436: left on mode power, end of cycle power and off mode power. In simple terms, these three IEC modes are as follows:

Left on mode

- The dishwasher door is opened within 1 min of the end of the cycle. The dishwasher is not turned off by the user.
- Where the appliance does not have power management (mode persists) then the power is measured for 30 min.
- Where the appliance does have power management which automatically reverts to off mode (<10 min), then the power is measured for the duration of this mode and the duration and average power recorded.
- There is no direct equivalent to this mode in AS/NZS2007.1.

End of cycle mode

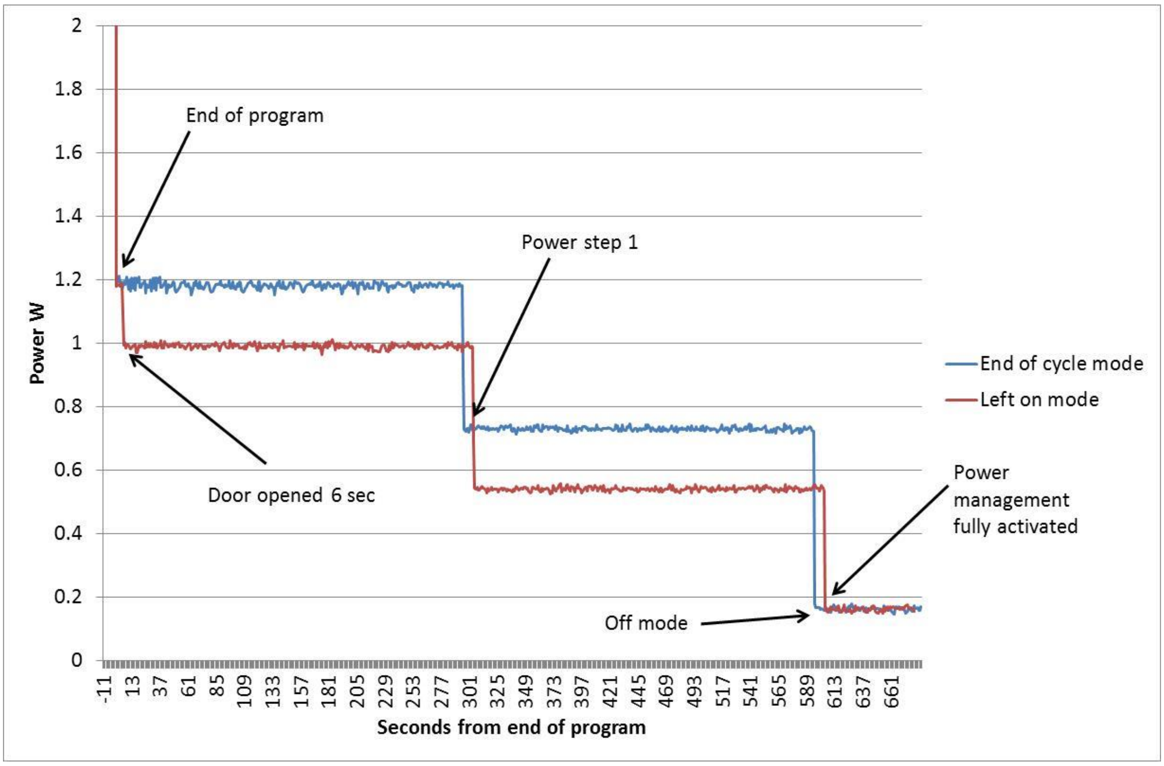
- This is the same as left-on mode except that the dishwasher door is not opened.
- This is equivalent to left on mode in AS/NZS2007.1 except that power is measured for 30 min (power management was not envisaged when the AS/NZS standard was written).

Off mode

- The dishwasher is turned off by the user or automatically turns off after a cycle when power management is automatically activated.
- Power is measured for not less than 10 min.
- This mode is equivalent to off mode in AS/NZS2007.1.

While both test machines had power management options, the round robin specification required the power management for Machine A to be disabled while the power management for Machine C was activated. Interestingly, the left on mode (with the door open) had a lower measured power in all laboratories when compared to the end of cycle model (door closed). A plot of the power profile for left on mode and end of cycle mode is shown in Figure 3.

Figure 3: Standby power trace for Machine C



It appears that the power management in Machine C operates for around 5 min at an intermediate power and then a further 5 min at a lower power before reverting to off mode. This occurred in both end of cycle mode and left on mode. This illustrates why it is important to log data at 1 sec intervals so that automatic changes in mode can be evaluated accurately at the completion of data collection. IEC62301 (standby power) requires data collection at 1 sec intervals.

Machine C appears to fully activate the power management after about 597 sec (almost 10 min) from the end of the program for end of cycle mode (no door opening). This appeared to be slightly delayed in left on mode where the appliance door was opened 6 sec after the end of the program (program timer showed 0:00 remaining). It appears that the small delay was due to the door opening, but it may be just variation in the dishwasher control.

The results for all the test laboratories are set out in Table 18 to Table 20.

Table 18: Left-On Mode Power

	Left on Mode Power (W)		Left on Mode Duration (minutes)	
Laboratory	Machine A	Machine C	Machine A	Machine C
Laboratory A	3.60	0.77	30	9.95
Laboratory B	3.49	0.80	30	10.04
Laboratory C	3.50	0.80	30	10
Laboratory D	3.08[1]	0.81	NR	10.1

Note 1: Data for Machine A Lab D has been carefully checked. NR is not recorded.

Table 19: End of Cycle Mode Power

Laboratory	End of Cycle Mode Power (W)		End of Cycle Mode Duration (min.)	
	Machine A	Machine C	Machine A	Machine C
Laboratory A	3.90	0.956	30	9.95
Laboratory B	3.83	0.980	30	10
Laboratory C	3.86	0.983	30	10
Laboratory D	3.85	0.987	NR	10.1

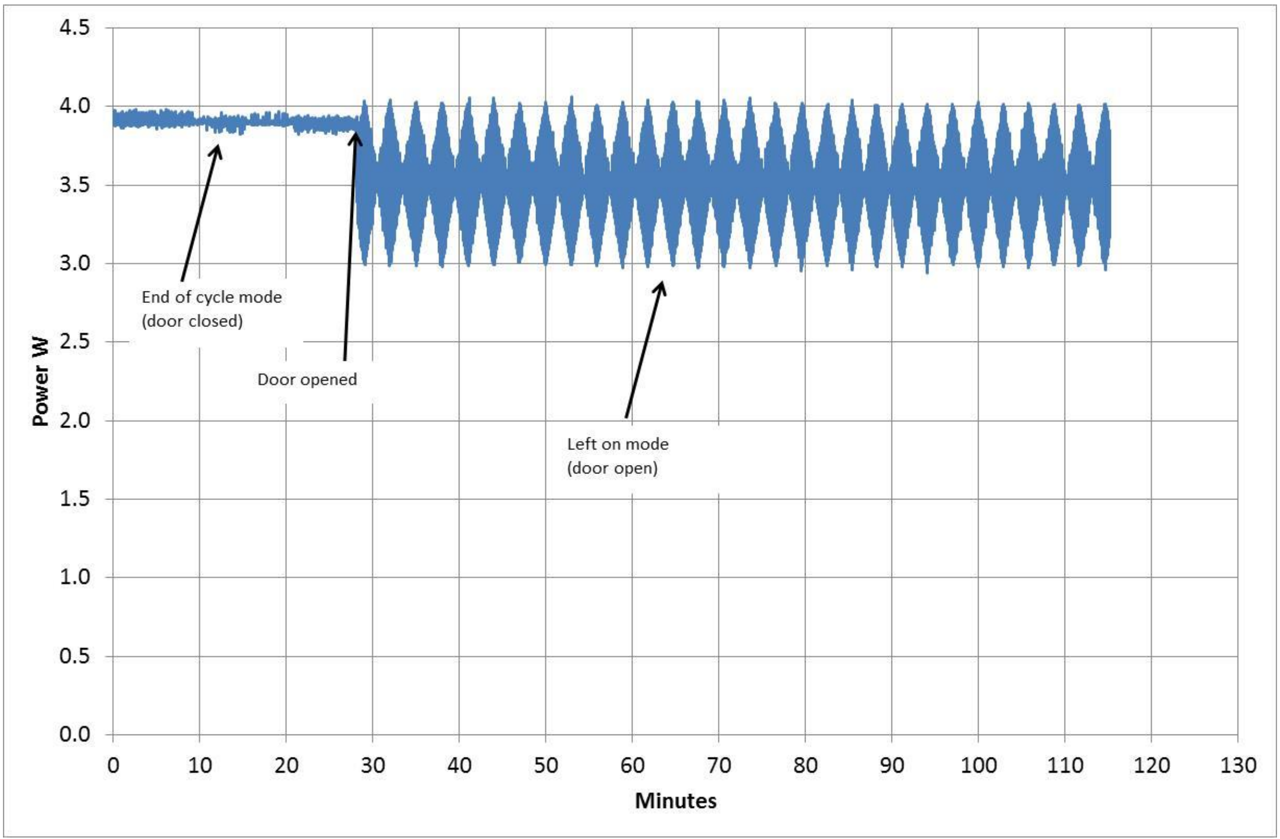
Table 20: Off Mode Power

Laboratory	Off Mode Power (W)	
	Machine A	Machine C
Laboratory A	0.13	0.17
Laboratory B	0.16	0.19
Laboratory C	0.15	0.19
Laboratory D	0.15	0.19

All laboratories achieved very similar results. In general terms the differences between labs were less than 1% for left on mode and end of cycle mode. For off mode, the percentage variation was higher, but the absolute differences across laboratories were generally small at <0.03 W, which is within the required uncertainty specified in IEC62301 for loads under 1 W.

Machine A turned out to be quite difficult to measure. The end of cycle mode (door closed) appeared to persist for an indefinite time and all labs obtained a measurement of close to 3.85 W. The measurement of left on mode was more difficult as the machine appeared to have an oscillating power level once the door was opened, as set out in Figure 4. This shows that left on mode (door open) has a saw tooth power pattern. Analysis revealed that this has a poor power factor. The discrepancy in Laboratory D for left on mode may be the result of the program selected (unclear from available data).

Figure 4: Power trace for Machine A for end of cycle and left on modes



There are several issues that may create problems in the way the standard is currently written. Firstly, the current text of K.2 defining left on mode and K.4 regarding end of cycle mode state that measurements start at the end of the ***cycle***.

In definitions cycle time and programme time are defined as follows:

3.1.16 cycle time: length of time beginning with the initiation of the cycle (of the selected programme), excluding any user programmed delay, until all activity ceases (i.e. the end of the cycle)

3.1.17 programme time: length of time beginning with the initiation of the cycle (of the selected programme), excluding any user programmed delay, until an end of programme indicator is activated and the user has access to the load

This suggests that the left on mode and the end of cycle mode should commence "when all activity ceases" at the end of the cycle. There appears to be a conflict in the text as the only way that it can be simply determined that all activity has ceased is where the power reverts to a steady state level. In the case of Machine C, this would be in 10 min after the end of the programme after the power management has been activated and the appliance has reverted to off mode. If the text was followed strictly, then there would be no left on mode or end of cycle mode as the machine reverts to off mode when activity ceases at the end of the cycle. The cycle time is 10 min longer than the program time.

There are two possible solutions. Firstly change the text in K.2, K.3, K.4 and K.5 from the end of the cycle to the end of the programme, which is probably the intended meaning. Or secondly, alter the definition of cycle and cycle time to clarify what is meant by “when all activity ceases”. This is much more difficult as it requires some knowledge about the machine and its activity.

The second issue is the potential error that arises from the procedure specified in Annex K. Currently K.2. states:

At the completion of any cycle the door of the dishwasher is opened within 1 min and the measurement shall begin immediately.

K.4 states:

At the completion of any cycle no action is taken by the operator and the measurement shall begin immediately or at the latest after 1 min including adjusting measurement devices.

Notwithstanding that *cycle* should be *programme* as discussed in the above text, this means that the permitted variation from lab to lab could mean that some labs start the measurement immediately at the program end while others commence 1 min after the end of the program. For Machine C there are several power levels that exist. These are:

- At the end of the program with no door opening – power is about 1.18W
- At the end of the program with the door open – power is about 0.99W
- After a period of about 5 min the power automatically falls to 0.73 W with the door closed or 0.54 W with the door open
- After 10 min the power management fully activates and the appliance reverts to off mode – this power level appears to be unaffected by the status of the door.
- From the available data, it is unclear if a delay in opening the door will impact on the timing of the activation of power management to off mode (a 6 sec delay in opening the door appeared to delay both subsequent steps by 8 sec).

The average power over the period until power management is activated will be impacted to some extent on how quickly the laboratory is able to start measurements. Even high quality power meters should have their wiring configured so that they are suitable for low power measurements (for low power levels the supply voltage should be measured upstream of the current shunt, for higher power measurements the supply voltage should be measured downstream of the current shunt) and even where this is pre-configured it can take some time to switch the configuration and change the current range on the meter if necessary. Another issue is that many meters have their current range locked while data logging and have to be stopped to select a current range that is suitable for standby power measurements. For the raw data plotted in Figure 3, the average power over the period until power management is activated (around 10 min from end of program) has been calculated in Table 21. Where the power is measured immediately at the end of the program, the measured power is 3% higher than if it is started 1 min later (as permitted in the standard). This is obviously of some concern.

Table 21: Machine standby power measured over periods permitted in IEC60436

Mode	Power over 10 min	Power over 9 min
End of cycle	0.956	0.931
Left on	0.765	0.742

There are other aspects of the behaviour of the appliance that may influence the results. If the power management activation is unaffected by the length of time to open the door, then this will also affect the result depending on how quickly measurements start.

IEC62301 provides clear guidance on the measurement of modes that are of limited duration. Clause 5.3.2 states:

Modes that are known (based on instructions for use, specifications or measurements) to be of limited duration shall be recorded for their whole duration. The results for such modes shall be reported as an energy consumption (Wh) and duration together with a statement that the mode is of limited duration.

The approach for measuring end of cycle and left on mode where power management is present in IEC60436 Annex K, which is an average power measurement until power management is activated, appears to partly conflict with IEC62301 as set out above. In addition, Clause 5.3.3 average reading method in IEC62301 is not permitted for cyclic or limited duration modes. It is suggested that IEC60436 be adjusted to record energy and duration for these types of modes in accordance with IEC62301.

Observations regarding test laboratories

This section sets out some broad observations regarding the test laboratories that participated in the round robin.

All laboratories have the ability to actively control and maintain ambient conditions and meet IEC requirements, including active temperature and humidity control. All local laboratories are using high quality energy instruments and follow accreditation procedures for calibration and traceable references, so this is unlikely to be an area of significant concern. All laboratories used high quality temperature measurement systems that meet current accreditation requirements and comfortably meet IEC requirements.

Measurement of relative humidity is undertaken using a range of instruments and the overall uncertainty was generally 2% to 4%. Accreditation bodies in Australia like NATA now tend to take instrument uncertainty into account when assessing compliance with the allowable range of conditions. Given that the permitted relative humidity is 55% ±10%, accreditation requirements may require conditions to be held with the reading range 49% to 61% if there is an uncertainty of 4%. Depending on the interpretation of the standard, most laboratories would find this achievable (although tight at times).

Mass measurement is important for soils used in the dishwasher test, and all laboratories appeared to have adequate and accurate instruments for this purpose. Instrument resolution and uncertainty is critical when the mass of soils deposited on load items is being measured.

Some test laboratories used one recording system to monitor energy and voltage and a separate system for recording ambient conditions. Sometimes these were recorded at different time intervals. This was generally not an issue as long as the ambient data records were available for merging with the energy and voltage records. Different formats also made data merging and integrated analysis of the data less straight forward in some cases. Difficulty in access to data sometimes makes verification of test conditions more time consuming and awkward.

One laboratory did not use a regulated power supply but was able to comfortably meet the voltage requirements (in this case supply voltage was set using a variac). This obviously depends on the local supply and supply system variations. Other labs used either a voltage regulator (that passed through mains frequency to the test appliance) or a UPS type system that could run independently on any voltage. Some laboratories had limited ability to fine tune the supply voltage at the appliance once the set point on the regulator output was selected (e.g. 230V). The ability to fine tune the voltage supply at the point of connection with the appliance (e.g. through use of individual variacs) is an area where some laboratories could enhance the operation of their laboratory in accordance with all standards.

Not all laboratories undertook continuous recording of water supply pressure, but manually read pressure gauges were fitted in all cases. However, all labs had systems where the supply pressure could be controlled accurately throughout the test using an automated control that maintained the target test supply pressure within a defined range.

Feedback to IEC

This section sets out a range of issues that came to light during the Australian dishwasher round robin and where individual test labs, the project managers and the Australian/New Zealand national committee are making recommendations for consideration by IEC SC59A (dishwashers). It is hoped that some of these may result in amendments to IEC60436.

Ambient air temperature

All test personnel found that the room temperature of 23°C is verging on uncomfortable when actively undertaking normal tasks in the test laboratory. Research in Australia shows the average temperature of living areas in Australian homes to be 21°C (population weighted Australian average). Note that these are annual averages. Average temperatures in New Zealand homes are a few degrees cooler. While it is accepted that common temperature conditions for all wet products is essential for labs testing multiple product types (clothes dryers, dishwashers and clothes washers), the actual temperature is not all that critical in terms of the measured value. The ambient temperature appears to be somewhat arbitrary, so they should be comfortable for laboratory personnel and be more relevant to room temperatures found in homes.

Recommendation 1: IEC could consider changing the test conditions as follows:

a) Change ambient test temperature back to 20°C (as was the case for all wet appliances until recently) in a coordinated fashion for all wet appliances or relax the ambient temperature requirement to be 20°C to 25°C with no specific target temperature (see discussion in the next point); and

b) Add an additional requirement to make mean and permitted variability clearer (see next point).

Temperature and humidity limits

Currently the standard requires control of the test room temperature to within 23°C ± 2K and relative humidity at 55% ± 10%. This is quite a narrow temperature range and quite a large humidity range. In practical terms, the room humidity will have little impact on the dishwasher test, except for the drying of soils in the air drying method, where relative humidity and to a lesser extent air temperature may have some impact on the residual moisture left in the soil. Ambient temperature and humidity during the operation of the machine will have no impact on the performance of the machine. The relative humidity during a drying evaluation is likely to have some impact on the result, so this should be carefully controlled for drying performance tests if this is shown to have an impact – some investigation is warranted.

A range of tests were conducted on plates in an oven at 80°C to examine how quickly they cool. Measurements revealed that the time constant for dinner plates was 7.6 min and for the soup bowls was 6.9 min. That data suggests that these load items will be close to the ambient temperature after the minimum time period specified in 6.5.2 as set out in Table 22.

Table 22: Predicted cooling profile for dinner plates and soup bowls based on cooling tests

Time out of oven min	Plate temp °C	Bowl temp °C
0	80.0	80.0
5	52.5	50.7
10	38.2	36.5
15	30.9	29.6
20	27.1	26.2
25	25.1	24.5
30	24.1	23.8
35	23.6	23.4
40	23.3	23.2
45	23.2	23.1
50	23.1	23.0
55	23.0	23.0
60	23.0	23.0

Notes: Cooling curve predicted using time constant equation.

Load items prepared in the thermal oven will generally be close to ambient temperature at the start of the test so room air temperature during soil preparation and oven heating does not need to be controlled. However, is the dried load is stored for some days (as is currently permitted), humidity may have some small impact on the moisture content of the soils prior to washing. Analysis has shown that thermal mass of the load has some energy impact (around 4.8Wh per K for 12 place settings), so there may be a case for having an energy correction for the initial load temperature for both the air drying method and for oven drying method if the temperature range is relaxed or where the temperature is at the current extremes of the allowable range. The dishwasher also has some thermal mass (around 5.5Wh/K for the test dishwashers), so an initial ambient correction for that may also be warranted. More analysis on this issue is provided later.

Recommendation 2: IEC should consider a relaxation of the temperature requirements during soil preparation and dishwasher testing, such as 20°C to 25°C during soil preparation, testing and evaluation. This is different to current requirements as a target of 23°C means that the lab should be actively managing the room temperature to achieve that target temperature. There is no apparent rationale for having humidity control for oven dry tests, where tests are done immediately. However, the relative humidity requirements could be tightened during drying evaluations where it is shown that this has some impact on the results. See the later point on instrument uncertainty. The inclusion of an energy correction based on the load temperature and dishwasher temperature at the start of the program should be investigated and implemented as this has been shown to be significant.

Guidance on placement of ambient sensors

Currently there is no specific guidance on the placement of ambient temperature and humidity sensors in the test room. It is important that sensors be placed in a representative position but away from any direct influence from any heat sources or sinks such as test appliances and conditioning equipment. The standard could also include some limits on air movement, which are not currently specified. It would be preferable that temperature sensors also have a low thermal mass in order to pick up short-term changes in ambient conditions.

Recommendation 3: Consider including in the standard specific guidance on the placement of ambient temperature and humidity sensors in the test room. Suggested requirements are:

- Placement should be in a position that will measure a representative value of the test room.
- Sensors shall be in a position that is not directly influenced by any appliances under test.
- Temperature sensors shall be shielded from any heat sources or sinks that are more than 5K different to the ambient conditions and that are closer than 5 m.
- Air movement at a position close to the appliance test position shall be ≤0.75m/s under normal test room configuration and operating conditions.
- All air temperature sensors shall have a time constant in air of less than 30 sec (tentative suggested value).

Instrument uncertainty

Currently instrument requirements are set out in Annex T. Specification of accuracy, as opposed to uncertainty, is imprecise and is not favoured by accreditation bodies.

Recommendation 4: IEC could consider defining instrument requirements in terms of as expanded uncertainty (k = 2) rather than accuracy, as this is now used routinely by accreditation bodies. For a normal distribution the coverage factor k = 2 corresponds to a 95 % confidence level, which is the recommended level for most parameters and instruments.

Allowable variations in parameters

All parameters in the standard are defined in terms of a target parameter and an allowance tolerance. Clause 5.1 states:

> *The tolerances specified for parameters within this International Standard, using the symbol '±', indicate the allowable limits of variation from the specified parameter outside which the test or results shall be invalid. The statement of tolerance does not permit the deliberate variation of these specified parameters.*

This suggests that laboratories are required to aim for the nominal test condition and maintain this within the permitted range. Where accreditation bodies reduce the allowable range by the overall uncertainty of measurement, this can make the requirements very tight for some parameters.

Another issue is variability of the ambient conditions. If a dishwasher operates for 2 hours and the requirement is for voltage to be held at 230V ±2%, this means that voltage must remain in the range 225.4V to 234.6V throughout the test. If there is a small perturbation in the supply for say 1 second out of 7200 readings that exceeds this fixed range, then under the current interpretation, this test result would be invalid. Clearly, such a minor excursion will have negligible impact on the result. One way to overcome this issue is to specify a tolerance for both the mean conditions and the variability of the conditions. For temperature, for example, this could be defined as:

- The mean temperature recorded during the appliance operation shall be in the range 23°C ± 2K.
- Two times the standard deviation of temperature recorded during the appliance operation shall be less than 1.0K.

This type of definition will require labs to target 23°C but the resulting average temperature must be within 21°C to 25°C. The variability of the measurement will also have to be fairly low at 1K, but small, short term excursions outside of the permitted range would be permitted. This is an illustrative example and the permitted range for the mean temperature and the permitted standard deviation can be independently varied in order to precisely define the permitted values for the relevant test parameter.

Recommendation 5: IEC should consider defining permitted variations in temperature, humidity and voltage as the permitted range for measured mean and a separate definition of permitted variability, which is generally two times the standard deviation of the measured values. Suitable values for both permitted range and permitted variation would need to be developed for each parameter. An example of this approach is included in IEC62552-1.

Data recording

Currently IEC60436 does not make any statements about the recording of data during the test, although this was implied for the old cold water correction (now deleted). Given that parameters such as supply voltage, ambient temperature and humidity all have target requirements and a permitted range, it is implied that these parameters need to be recorded on a regular basis throughout the test. It is also good practice to record instantaneous power, energy and water volume throughout the test at regular intervals. The participating Australian test laboratories all use high quality digital power analysers to record electrical parameters and a range of other systems to record ambient and other conditions.

Recommendation 6: It is recommended that the standard require that parameters such as voltage, energy, temperature and relative humidity be recorded at equal intervals of 1 min or less throughout the test (not necessarily on the same system or at the same interval for different parameters). This will provide a high level of traceability of data and will allow an accurate quantitative assessment of the standard requirements to be undertaken. It will also facilitate the application of the new variability requirements proposed.

Standby power measurements

Currently IEC60436 references IEC62301 for low power measurements in Annex K. As set out in the results section, there are several concerns regarding how standby measurements are specified in IEC60436.

Recommendation 7: The following recommendations cover Annex K Additional aspects of energy consumption of dishwashers.

In K.1 the following sentence is unclear:
Power measurements for left on mode, end of cycle mode, off mode and delay start mode shall be made in accordance with the requirements of IEC 62301 except for 5.3 .

It is unclear whether the reference to 5.3 is the clause in IEC62301 or IEC60436. If it is IEC60436 this makes no sense as 5.3 is about supply voltage and frequency. If it is to IEC62301, then this also makes no sense as Clause 5.3 sets out the measurement method for determination of power and energy in that standard and is the most important clause in that standard. This sentence should be clarified and corrected. Further, there is a space before the full stop.

As set out in the results section, it appears that the intended meaning is for the procedure to commence at the end of the programme (when the load is indicated as available to the user), rather than the end of the cycle (when all activity ceases) as currently defined. If end of cycle was interpreted in accordance with the standard, Machine C would have no end of cycle mode or no left on mode. So all mention of cycle should be changed to programme in Annex K. This may also require end of cycle mode to be changed to end of program mode. Presumably there will be resistance to the proposal to change the mode name. In this case change cycles to programme as follows:

- K.2 line 1
- K.3 line 4
- K.4 line 1
- K.4 line 4
- K.5 line 4

As set out in the results section, the latitude in the measurement method in Annex K will result in some significant differences between labs just due to the permitted time variations until measurements commence. This needs to be tightened up so that there is no significant variation between labs. Where an appliance has short duration modes that change automatically, IEC62301 requires the use of 1 sec sampling. It also states that the energy and duration of each power level should be reported. This is in conflict with IEC 60436 Annex K, which specifies an average power measurement for a period that may include several power levels of varying duration, as was observed for Machine C. Averaging power for a mode that has several power levels is potentially inaccurate. Annex K should be aligned with the requirements of IEC62301 and report energy or average power and duration of each power level after the completion of the program.

Test series

Currently IEC60436 specifies a test series of five or more test runs in order to obtain a valid result. IEC60436 attempts to combine an assessment of the filter performance with an assessment of the cleaning performance. As load items should be fully reconditioned between test runs (able to score 5), there is no compelling reason why multiple runs are necessary, except to improve the certainty of the result of the machine under test. Reallocating resources to a single test run on five different machines of the same model (for example) yields much better information on the production variability, which is of much greater interest for regulators for programs such as energy labelling. A variation in run to run repeatability will be averaged out where single tests are undertaken on multiple machines.

The test machines used in the round robin were repeatable in their operation and undertaking an additional four runs after the first run yielded little additional information. Mandating five test runs is very onerous in terms of resources and time in order to get a valid result. The IEC test method should be generic and it should define a type test; that is, a single run on a single machine. This can be applied in the most appropriate way in different regions to achieve a desired certainty of result. Depending on the application and the desired certainty of the result, it is then possible to define how many runs on a specific machine are required and how many different machines may need to be tested to meet local requirements. Mandating five runs in a test series already conflicts with local regulatory requirements in a number of regions and encourages regions to move away from alignment with IEC standards. Australia and New Zealand are likely to vary this element of the IEC standard for local application if is not altered in IEC.

Recommendation 8: IEC should alter the dishwasher standard (and the clothes washer and clothes dryer standards for that matter) to specify a single test on a single machine, with additional guidance on multiple test runs and sampling as a separate advisory annex. Filter cleaning should always be undertaken between tests on test machines. Filter cleaning should always be undertaken between tests on the reference machine (this should be done irrespective of whether the definition of a test series is changed or not).

Separation of filter cleaning performance

Currently cleaning performance is conducted for at least five runs without filter cleaning between runs (on the test machines and the reference machine) in order to assess whether the filter is classified manual or automatic. A separate set of tests should be specified without filter cleaning only to assess this manufacturer claim where it is necessary to do so.

Recommendation 9: Separate the filter performance assessment from the evaluation of energy, water, cleaning and drying performance.

Application of W_D for drying scores

Currently the drying performance is assessed for sequential runs. The standard states that if W_D is >0.10 then additional runs (up to eight) are to be undertaken. It is well known that drying performance can be variable, particularly on units that have lower performance. However, the standard should not be mandating multiple runs for drying in order to get a valid result for models that have more variable performance. As with cleaning performance, the test should be a single run on a single unit. The number of repeat tests and the number of samples tested can be adjusted to give the desired level of uncertainty of the final result, depending on the objective of the tests. Guidance on how to calculate W_D should remain in the standard where multiples runs are undertaken.

Recommendation 10: Change the standard so that it is a single run on a single machine. Include guidance on multiple runs and the use of W_D in an informative annex.

Drying index

In the Australian round robin the drying performance was more variable than cleaning performance, as expected. The use of the reference machine drying score to calculate a drying index did improve the reproducibility marginally (compared to using raw drying scores), but the underlying variability was still around 4%. AS/NZS2007.1 in the past has used raw drying scores and has not calculated an index based on the reference machine. However, Australia and New Zealand are likely to change to a drying index once the IEC test method is adopted.

No changes to IEC60436 are proposed.

G590 versus G1222 SC

The Australian round robin laboratories had a range of reference machines available. Two laboratories had the G590 and G1222 SC and two laboratories only had the G590. Some comparative tests were undertaken between the G590 and the G1222 SC references when run in parallel. While the number of tests was quite limited, it does appear that these machines may have different underlying performance on the IEC/EN Universal 65°C reference program when operated in parallel (around 8% lower washing score for G1222 SC). This is of some concern, as the assumption is that these machines deliver equivalent performance and this means that different labs will achieve a different washing index, depending on the reference machine used. While the standard says that a Type 1 machine (G590) can be used if the performance can be shown to be equivalent, this is not practical for most labs. This is an issue that will have to be addressed by local regulators if the IEC test method is adopted.

Recommendation 11: Undertake additional evaluations of the G590 and G1222 SC reference machines to establish whether there are any underlying performance differences in cleaning and whether maintenance or calibration approaches can be used to minimise these. Seek advice from Miele on additional checks and calibration procedures for Type 1 and Type 2 reference dishwashers.

Overlap of test machines and the reference machine cycles

Currently clause 6.6.2 requires that part of the cycle of all test machines shall run at the same time as part of the reference machine cycle. The inclusion of combined cleaning and drying tests means that around 20 min to 30 min is required between the program end of each machine to evaluate the drying performance for each test and to organise the load for later soiling evaluation. If there are three or more test machines to be run a parallel with the reference machine, in many cases it is not possible to organise a window where all test machines are operating at the same time as the reference machine. The soiling for both the reference machine and the test machine must still be prepared from the same batch and by the same people.

Recommendation 12: IEC should consider a larger operating window in clause 6.6.2 that will allow more test machines to the operated in parallel. A suggested approach is to alter the text so that test machines and the reference machine must all be operating within a four hour window. Suggested text:

Test machines and the reference machine shall be scheduled so that the reference machine cycle and all test machine cycles partly or fully overlap with a four hour time window.

Time between test runs in a series

Clause 6.5.2 second last paragraph regarding a maximum of four days between test runs. This is difficult to achieve using the air dry method with a normal weekend allowing say a Friday to recondition the test loads before soiling the following Monday and so the machine runs on Tuesday (i.e. five days or potentially six days if a long weekend). This comment becomes irrelevant if the test is changed to a single run on a single machine, which is strongly recommended.

Recommendation 13: Relax this requirement to allow a longer period between consecutive runs in a test series.

Air drying times and clarification of text

Currently Clause 6.5.2 states: "*Soiled tableware items that have been prepared by the oven drying method may be stored under ambient conditions for a maximum of 4 days when covered by an opaque plastic cover sheet*." It is not clear whether this text means that the soiled load may be stored for up to four days BEFORE oven drying or AFTER oven drying. The text "have been" implies that the oven drying has already happened, but this needs to be clarified in the text.

Currently the air dry method sets a time limit of 15 h to 18 h. Original tests showed that soils were completely dried in around 6 h to 8 h, so 15 h was seen as a very safe drying period to allow the load to reach equilibrium moisture content. However, the upper time limit of 18 h places a lot of restrictions on laboratories that use the air dry method. It is proposed that the storage time be extended for up to four days (as per the oven dry method) as long as the load is covered by an opaque plastic sheet.

Recommendation 14: Clarify whether the text in 6.5.2 means that the four days storage is permitted BEFORE or AFTER oven drying. Suggest text:
Soiled tableware items that have been soiled and oven dried using ~~prepared by~~ the oven drying method may be stored under ambient conditions for a maximum of 4 days prior to use in a test run if covered by an opaque plastic cover sheet.

Modify text in 5.6.3 as follows: The total dry time shall be not less than 15 h and may be extended up to 4 days prior to use in a test run ~~to 18 h~~ and shall be in accordance with one of the options below. Where the load is placed on a level surface for more than 24 h it shall be covered by an opaque plastic cover sheet.

Drying and cleaning evaluation of pots

Currently clause 7.2.2 and 7.3.1 require the pots (items S1a and S1b) to be evaluated as four items: inner bottom, inner wall, outer surfaces and the pot as a whole. The rationale for this is not entirely clear (perhaps a larger item should carry a higher weighting in the cleaning score?) and it is not clear why this approach is not applied to other large items such as the platter and large bowl. Putting this philosophical question aside, the current wording states: "*additionally, give one score over the entire pot*". Some labs find applying a score to three parts of the pot and then a separate score to these three parts combined conceptually awkward. An alternative approach would be just to award three scores for the three specified areas and to leave out the overall score. Two other large items could be scored similarly to give them more weight (e.g. inside and outside of bowls, top and bottom of platter) to keep total scores the same.

Recommendation 15: Review the rationale for scoring the pots differently. Clarify the wording or the approach for pots and consider eliminating the overall score. Consider adding additional scores for sections of other large items to provide more influence on the cleaning score.

Cleaning scores for glasses – air dry method

Annex F states that the air drying method for glasses with milk cooked in the microwave should be in the range 2.9 to 3.9. As only half of the glasses are soiled, it is important to keep the glasses that were originally soiled glasses separate from the originally clean glasses where combined drying and cleaning evaluation is undertaken. A note to this effect should be added to F.2. Some labs found that marking soiled glasses with a black pen on the white brand marking helped to identify these items in the later cleaning evaluation. Round robin data showed that the clean and dirty glasses were similar in some labs (in some cases soiled glasses scored better than clean glasses), which suggests that some of these items may have been mixed up during the drying evaluation in some labs.

Cleaning scores for glasses were quite variable across the laboratories, which suggests variation in preparation and evaluation. It is noted that the IEC round robin results also appeared to show a very wide range in cleaning scores for glasses.

Experience from the Australian round robin suggests that the milk is severely cooked on in the microwave. It is unlikely that oven drying of the soiled milk glasses would make any significant difference to the overall scoring for milk soil, so it is unclear why the benchmark scores are so different for oven and air drying.

The issues of whether milk soiled glasses should be put in the thermal oven and the adjustment of microwave cooking times are discussed in a later recommendation.

Recommendation 16: Add a note to F.2 to make it clear that the originally soiled glasses should be tracked carefully when combined drying and cleaning evaluation is undertaken. Spoons, which also only have half of the items soiled, should also be tracked carefully if cleaning scores for soiled and unsoiled items need to be differentiated. Examine whether more consistent cleaning scores for glasses can be obtained by further refining the method. Review expected cleaning scores for milk soil on glasses for air and oven drying.

Load item specifications

Annex B sets out the detailed specification of load items, including mass. A tolerance of ±5% is permitted on the nominal mass. As there are a number of new items in Edition 4, these were purchased new from WFK in Germany for use in the round robin. When checking the specifications of these items (and existing items like glasses), it was noted that not all were within the specification in Annex B. Some of the details are set out below:

- Item A3 dessert bowl – 1 out of 24 below specification (one at 5.2% below)
- Item B2 melamine dessert plate – 23 out of 24 above specification, average 132.7g (10% too heavy on average)
- Item B3 saucer – 24 out of 24 below specification, average 139.7g (11.1% too light)
- Item B4 cup – 13 out of 24 below specification, average 106.3g (6.5% too light)
- Item S2 glass bowl – 4 out of 4 above specification, average 353.8g (20% too heavy)
- Item S3 oval platter – 4 out of 4 above specification, average 837.2g (27.8% too heavy)
- Item S6 serving fork – 3 out of 4 below specification, average 35.6g (7.0% too light)
- Item A5 glass – 34 out of 60 above specification, average 111.8g (6.3% too heavy)

More information is available on request.

Recommendation 17: Specifications in Annex B should be adjusted to fit the available items or the recommended items changed so that they lie within the specification. A larger tolerance on mass may also be required for some items.

Preparation of oats

Clause 6.4.6 sets out the preparation for oats. 50g of oat flakes are added to 750ml water and 250ml of milk. This is a mass ratio of around 1:20. Laboratories noted that the porridge (cooked oats) was extremely runny in its consistency. When items like spoons are dipped in the cooked porridge, then only a thin coating of liquid mixture adheres to the spoons with very few oat flakes. It is understood that the primary function of oats is to provide a starch soil. The concern from Australian labs is that the IEC preparation of oats can lead to inconsistent soil application with oat flakes on some items and no flakes on others. It is not clear how much starch is contained in the liquid part of the oats mixture.

For reference, normal porridge consumed by humans is recommended for preparation at the ratio by volume of 1 part oats to 3 parts liquid (water and or milk). By mass, this ratio is approximately 1 part oats to 6 parts liquid. When cooked properly, the porridge should form a solid gelatinous mass. So the IEC preparation approach has more than 3 times as much liquid per mass of oats as you would expect in normal food preparation in the home. The resulting mixture is more like soup than porridge.

Australia currently specifies a baby rice cereal as the equivalent soil. This is fairly fine in texture and is applied to all load items with a brush. The use of oats is desirable because it is a widely used food and readily available. An alternative preparation approach for oats has been tried. This involves putting dry oats in a blender, sieving the processed oats through a 1.2mm sieve and then cooking the sieved powder to be a porridge with one part processed oats to four parts liquid. Some tests are being undertaken on this at the moment in Australia.

Recommendation 18: IEC should revisit the purpose of the oats as a soil and consider a preparation approach that is more in line with normal practice to produce a thicker mixture. More information on the blending and sieving approach will be provided by Australia when available.

Definition of plate edge

For items where soil is applied, the standard usually specifies that soiling is only applied up to XXmm from the item edge. The size of this clean rim varies by item.

Some items have a change of profile near the edge (e.g. dinner plates). One laboratory was not clear whether the XXmm of clean rim was measured along the surface, horizontally or along the direction of the rim (ignoring the change in profile).

Recommendation 19: Clarify wording in the standard for items where there is a change of profile near the edge of the item. Review the size of the clean perimeter for each load item and where possible, make sure that the specified clean perimeter falls on a natural change in profile or well away from (before) a natural change in profile.

Review of text in clause 6.5.3

Clause 6.5.3 states that:

All tableware items soiled according to 6.4, except the melamine bowls, shall be dried according to the procedure described below.

Clause 6.4.8.3 notes that margarine is applied to the melamine bowls and that this can be applied shortly before the test begins. However, the small pot is soiled with a margarine and spinach mixture. This could also be soiled just prior to the dishwasher operation (or it can be air dried – this will make no difference).

It is also unclear whether the small pot should be placed in the thermal oven, in which case the margarine will melt.

Recommendation 20: Clarify the intent and wording in the standard for the small pot for air and oven drying.

Variations in tea staining

One lab in particular noticed significant variations in tea staining from run to run. When saucers are stacked, the unglazed part of the saucer base can create micro-scratches on the saucer top surface (in the cup ring) and it is thought that this can make the saucers more susceptible to tannin staining.

Recommendation 21: Further investigations into micro scratches on the glazing surface and tannin stains should be conducted.

Tea staining approach for air drying

Currently the approach for tea staining is to place 120 ml of tea into each mug, 80 ml tea into each cup and 40 ml onto each saucer. For the oven dry method, all tea items are placed in the oven for 1 hour by themselves. The items are removed, the tea contents are then discarded and the tea items are dried with the remainder of the load in the oven.

For air drying, after 1 hour some tea is removed so that 20ml is left on each item. Most labs find this quite tedious to do (removing a different amount of liquid from each item type). The original concept was that the remaining 20ml of tea would evaporate in the remaining 14 hours of air drying. However, this does not occur and a significant amount of tea is left in each item after a further 14 hours. The standard requires that the discarded tea is placed into the base of the dishwasher (rather than put down the drain). This could impact on the water consumption of the dishwasher.

A proposal has been developed by the Australian laboratories. This is to leave the tea in the various containers for two to three hours, discard all the tea and let the items air dry as per usual for the remaining time. This would provide some additional time for tannin staining (comparable to oven drying) and then would allow all items to completely dry before placing them in the dishwasher for the test. In the light of the longer proposed time for drying, always completing the processing of the tea preparation in the early part of the process will give the most consistent results.

Recommendation 22: Amend the tea preparation procedure for air drying as follows:

Clause 6.4.3.5
After completion of tea application items shall remain at ambient conditions for a period of 2~~1~~ to 3 h to allow staining. ~~After the pre-drying period carefully remove 100 ml from each mug, 60 ml from each cup, and 20 ml from each saucer using a syringe.~~ Discard all ~~the removed~~ tea from the items after 2 to 3 h and leave them to air dry for the remainder of the drying period.

Clause 6.6.1
If the mugs, cups and saucers have been air dried ~~, collect the remaining tea from them before~~ place~~ing~~ these items in the dish racks. ~~Place the tea on the floor of the reference and test machines just before the start of the test cycle.~~

Scoring of soil

The standard is fairly clear about how an item is scored for soil as set out in Table 3. The concern is that some assessors tend only to assess soil area and do not assess, in parallel, the number of spots where the soil area is less than 50mm^2. Perhaps this could be more clearly demonstrated with some practical examples in an Annex.

AS/NZS2007.1 diagrams show examples of the specified soil area to scale. This would be a useful guide for assessors to have nearby to help them more accurately assess soil area during cleaning evaluation.

Recommendation 23: Include scaled area charts to illustrate different soil areas in a new Annex in IEC60436 with some examples of cleaning evaluations with combinations of soil area and number of spots.

Round Robin documentation

The following points appear to be discrepancies in the round robin documentation:

- Loading pattern photographs for the top shelf of the Miele C appliance inconsistent for glass placement between the two photos provided
- Row 180 in the data spreadsheet calculates a single drying index by diving the total drying score by 5 compared to the calculation on page 36 (7.2.3(3)/(4)) which divides by 2.
- Various clarifications and corrections for testing were included in the round robin specification (see Appendix A).

For noting only - no recommendation.

Minor discrepancies in the standard text

The following points appear to be discrepancies in the text of Edition 4:

- Air dried vs oven dried: Standard says to collect the remaining tea after air drying and tip into the machine (6.5.3), whereas during the oven drying approach all remaining tea is tipped out and discarded (6.5.2) – covered by the change in Recommendation 22.
- Clause 6.4.6.3 last item alternative load item seems to imply that a lab can substitute plates for bowls?

Recommendation 24: Review and redress these issues.

Dead water in supply spur lines

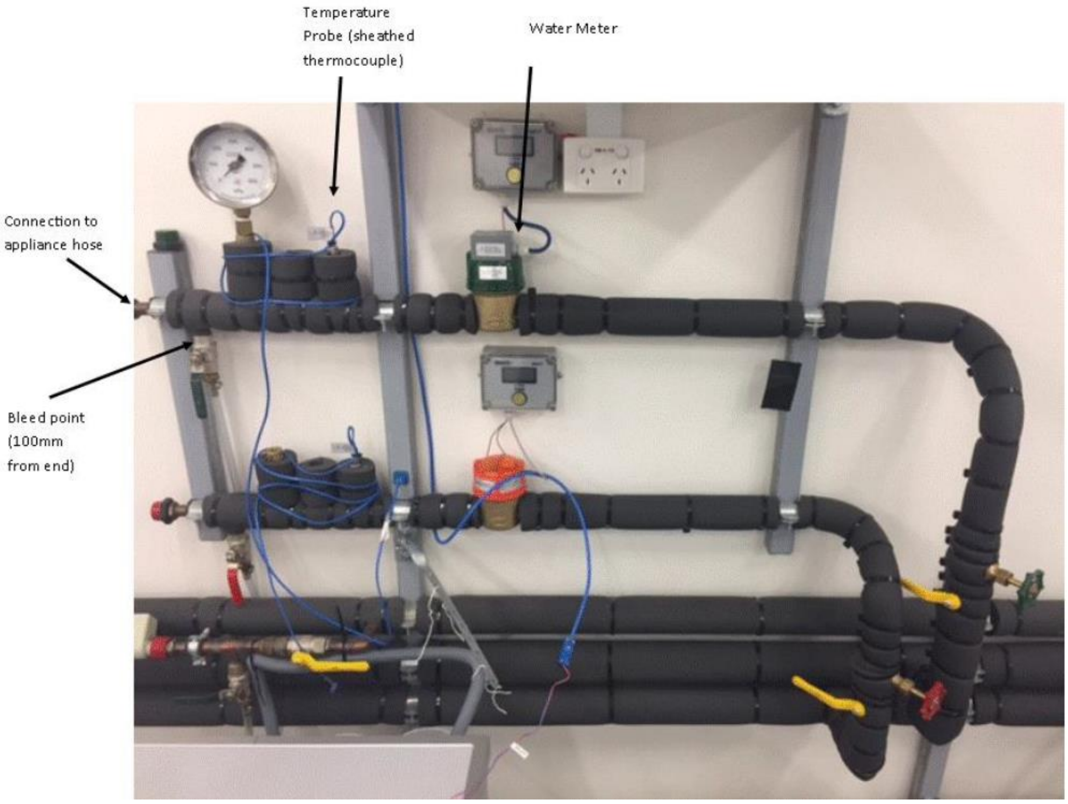
The water supply temperature in IEC60436 is 15°C and the air temperature is 23°C. This temperature difference creates an operational problem for all test laboratories and requires a circulating water system to ensure that the required supply temperature is maintained (stagnant water in pipes tends to warm towards ambient temperature). This issue would be eliminated if the ambient temperature and water temperature were the same. Even with circulating water systems, there will be some dead water in supply spur lines from the circulating water system to the appliance connection point. This spur pipe also has the supply temperature sensor and a water flow meter fitted in order to monitor water supplied to the individual appliance as well as a pressure sensor. The standard limits the dead water volume from the temperature sensor to the appliance connection point to 250ml (clause 5.6.2) (which could be as much as 400ml including the dishwasher supply pipes). This approach is supported in principle. The problem with this text is that the measurement device for temperature may be quite close to the appliance connection point (all Australian labs had less than 100ml between the temperature sensor and the supply point). But the requirement as written places no effective limit on the total dead water in the supply spur to each appliance. The main limitation with spur lines is that flow meters require a length of straight pipe before the meter (typically 5 to 10 diameters) and some straight pipe after the meter (typically 2 to 5 diameters) in order to reduce turbulent flow to maintain meter accuracy. This does place some constraints on the water supply configuration. It is recommended that some upper limit on the total volume of dead water in the supply spur be included in the standard.

Table 23: Details of configuration of cold water supply spurs in each laboratory

Lab ID	Spur diameter mm	Spur Length mm	Spur volume ml	Temp sensor to conn mm	Temp sensor to conn ml	Lagging mm	Bleed valve	Bleed used at start?
Lab 1	12.5	600	67	N/A	N/A	None	No	N/A
Lab 2	23	1730	656	410	170	9	Yes	Yes
Lab 3	17.8	880	219	270	67	9	Yes	Yes
Lab 4	17	2100	480	330	75	19	Yes	Yes

Note: Lab ID used in this table does no correspond to the normal Lab ID used elsewhere in this report.

Figure 5: An example of the water supply layout in one of the Australian laboratories



Clause 5.6.2 currently does not require a by-pass or bleed valve at the point of connection with the appliance. However, if present, this shall be operated before starting tests. The energy impact of 250ml at a temperature difference of 8K is only small (around 4Wh), nevertheless, this is good practice and means that every appliance test starts at the same condition. The standard should mandate a bleed valve at the point of connection with the appliance. However, as noted above, there is currently no limit on the volume of dead water in the supply spur, so in theory this could be many litres.

Another important item is that supply pipes (at least spur lines that are not part of a circulation system) should be lagged with suitable thermal insulation to slow the rate of temperature rise during periods when water is not being drawn or at least make this more uniform across laboratories.

All Australian laboratories used circulating water systems and three of the four had insulated spur lines. The lab with an uninsulated spur line had a small volume from the circulating main to the appliance connection. Analysis shows that for the round robin tests, the temperature of the water in the spur lines warms significantly between dishwasher fills. Some examples of this are shown in Figure 6 to Figure 8.

Figure 6: Cold water supply line temperature trace – Laboratory 2

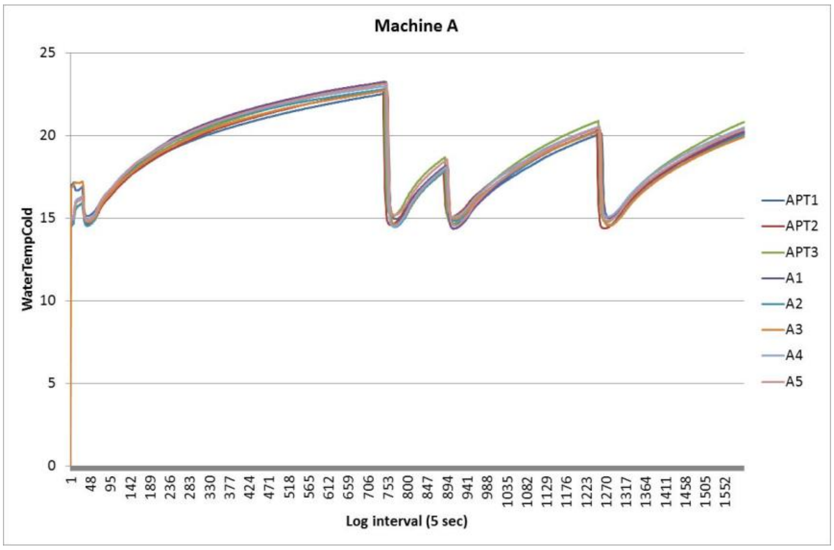


Figure 7: Cold water supply line temperature trace – Laboratory 3

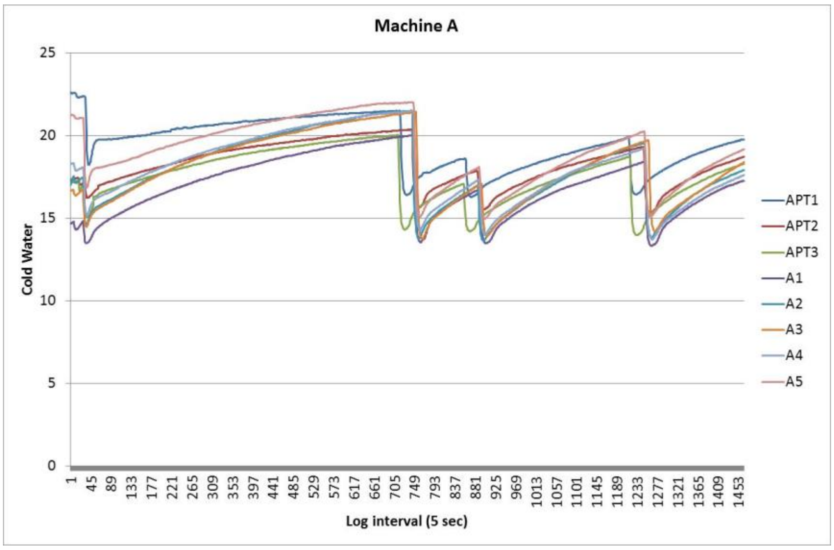
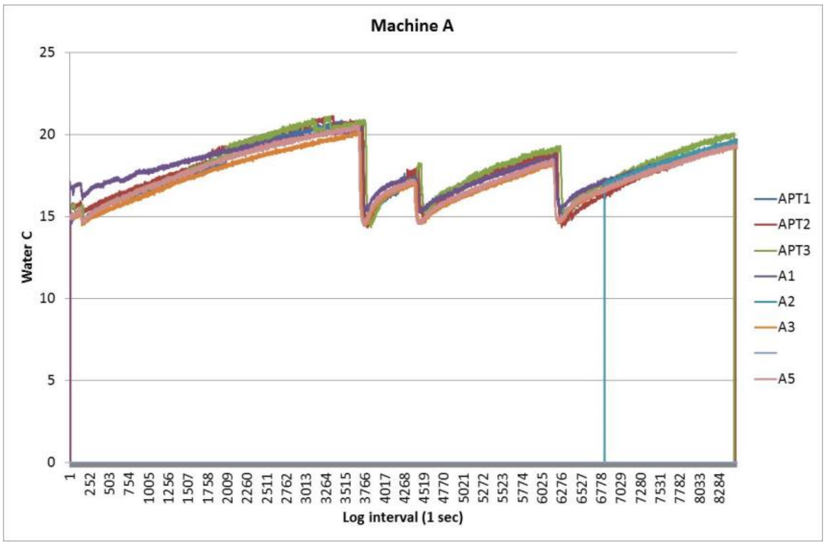


Figure 8: Cold water supply line temperature trace – Laboratory 4



In terms of products included in the round robin, Machine A is the most difficult to test as the appliance effectively draws little water for the first hour, so dead water in the supply spur line tends to warm towards ambient temperature. While all Australian laboratories have a bleed valve that can reset the water temperature at the point of connection to the appliance at the start of the test, it appears that laboratory 3 did not do this consistently before each test. While most tests start at close to 15°C in the supply pipe, it appears that the temperature rise in each laboratory varies somewhat. Three labs use closed cell nitrile rubber lagging on the spur lines.

The issue of water supply temperatures actually delivered to the appliance is discussed more in the next point.

Recommendation 25: Clause 5.6.2 should be amended to require a by-pass or bleed valve at the point of connection with the appliance. This shall be operated within 10 min of the commencement of the program on the relevant dishwasher to ensure that supply water is within the specified temperature range. All water supply lines where water is not in a circulating loop (e.g. spur lines to supply each appliance under test) shall be insulated with 10mm closed cell nitrile rubber or equivalent with an R value of 0.4 $K.m^2/W$ or better. The standard should also put a limit on the total volume of dead water in water supply spur lines that service each appliance. We suggest 600ml as a reasonable maximum. This is in addition to the current requirement of not more than 250ml from the temperature measurement point to the appliance connection. The current requirement of 250ml is very generous and a value of 125ml is recommended from the temperature sensor to the connection point.

Cold water energy correction

Edition 3 included a cold water energy correction for operations where heating takes place and/or where hot water is drawn into the machine (Clause 8.2.2 in Edition 3). This has been deleted in Edition 4. This is an important correction and its removal appears to be a serious technical mistake.

Dishwashers typically use between 8 and 20 litres of water per load, depending on the design. Most dishwashers undertake two heating operations, typically during the wash operation and the drying operation. The standard defines the cold water supply temperature as 15°C ± 2K. Looking at the round robin dishwashers, the total water consumption for Machine A was 9.2 litres and Machine C was 18.8 litres. If the cold water temperature was 13°C (coldest possible temperature) then the embodied water energy when compared to 17°C (the warmest possible temperature) would be 42.8 Wh for Machine A and 87.4 Wh for Machine B. This equates to 4.7% of the total electrical energy consumption for Machine A and 6.4% of the total electrical energy consumption for Machine C. While this difference would be hard to achieve in practice within the boundaries of the current requirements, it is possible on paper.

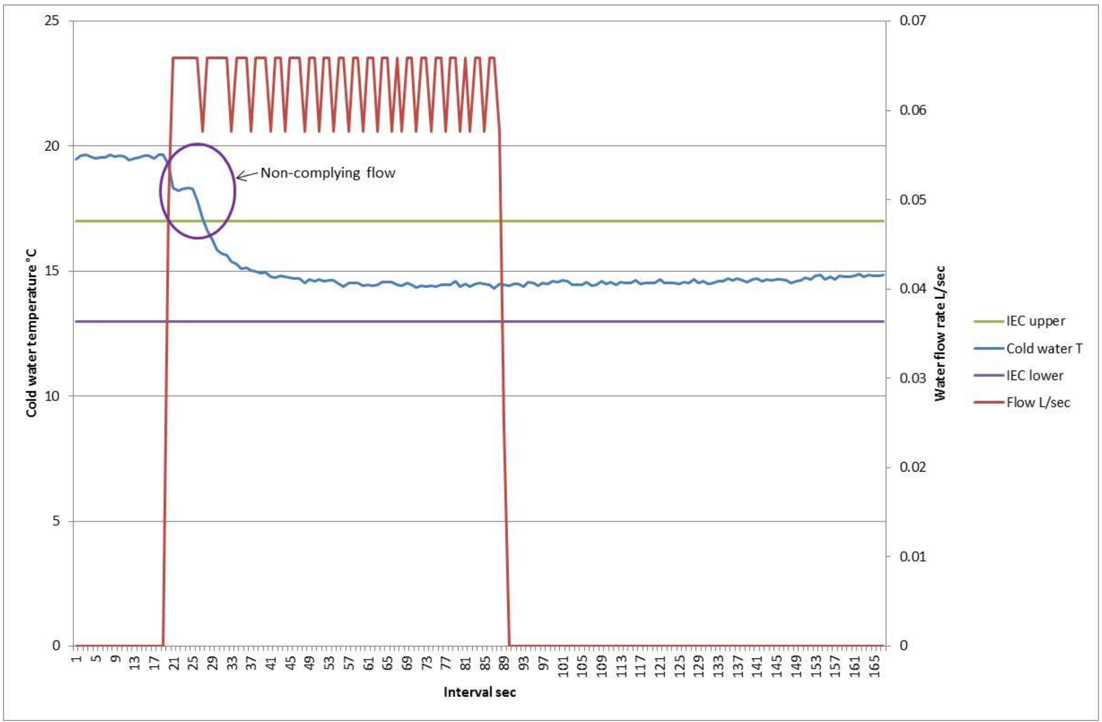
Analysis of data from the round robin shows that about 30% of the heating energy for each heating operation can be attributed to the heating the water, with the balance evenly split between the load and dishwasher itself. Based on an estimate of the thermal mass of the load based on the materials and mass, the specific heat of the load is about 4.7 Wh/K (12 place settings). Examining heating profiles from the round robin and the initial and end temperature for the wash and rinse operations for Machines A and C, it is possible to separate the thermal mass of the water, the load and the dishwasher. Machine A has a thermal mass of around 5.2 Wh/K while the water thermal mass is about 4.1 Wh/K. Machine C has a thermal mass of around 5.6 Wh/K while the water thermal mass is about 4.7 Wh/K (this is higher for Machine C as the water volume in the sump is higher than Machine A). This suggests that the water temperature is an important consideration when measuring the energy, as well as the initial temperature of the dishwasher and the load.

The initial temperature of the load and dishwasher will determine the initial thermal mass of the dishwasher system at the start of the test. This will have a direct impact on the energy consumption where the initial operation is heated or where there is little or no water drawn into the dishwasher (e.g. Machine A with on board storage). The impact of initial temperature may be reduced slightly where an initial cold rinse is undertaken before a heated wash (e.g. Machine C). Applying corrections for initial temperature of the load and the dishwasher may be warranted. However, there are some issues to consider. Firstly, data on the thermal mass of dishwashers is not generally available so this would need to be estimated. The thermal mass of the load can be calculated where an initial temperature is known.

As noted above, the supply temperature in IEC60436 is nominally 15°C ± 2K. However, looking at the supply temperature profiles in the previous section, it is clear that water in the supply pipes is often well outside of this permitted range as the stagnant water in the supply spur warms between draw-offs. In fact it is hard to know how to apply that part of the specification to practical laboratory data like that measured in the round robin. Consider the supply temperature profile in the following mid-cycle part of test snap shot for Machine C as illustrated in Figure 9. Clearly the initial part of this draw-off does not comply with the 15°C ± 2K requirement and it would be impossible for labs to meet this requirement throughout the test unless there was continuous bleeding of water supply during the test. The issue is that the 8K temperature differential between the water supply (nominally 15°C) and the room (nominally 23°C) means that cold water supply will always warm between draws. In practical terms there has to be some dead water in a supply spur for each appliance (see discussion in the previous section). The variation between labs testing to the standard could currently be quite large as there is no limit on the volume of dead water in a supply spur (that can heat up between draws) and there is no requirement for lagging on the pipe for a supply spur.

Most of these problems would of course be eliminated if the room temperature and the cold water supply temperature were both 20°C as per AS/NZS2007.1.

Figure 9: Temperature during a mid-cycle draw-off profile for Machine C



The only practical way to address these lab to lab anomalies is to apply a cold water correction to all water drawn by the machine back to a reference temperature of 15°C. Edition 3 of IEC60436 had a cold water correction for those operations that were heated or where hot water was drawn in. Given the very low water usage of most dishwashers now and the previous analysis that shows that most of the heat capacity is in the dishwasher itself and the load (rather than just the water), it makes sense to correct all water consumption as any excess or deficit in the supply water energy will be mostly carried over between non-heated fills (by the dishwasher and the load) and the supply temperature will fully and directly affect water intakes where there are heater operations.

This type of correction is simple to calculate. The correction for each sampling interval is given by:

$$E_c = \frac{Q \times (t_c - 15)}{0.860}$$

Where:
E_c is the cold water correction for each sampling interval in Wh
Q is the total water flow for each sampling interval in litres
t_c is the temperature of the cold water supply in degrees Celsius

It is recommended that the sampling frequency for this calculation be 5 sec or shorter. The thermal mass of the temperature sensor needs to be quite small – a time constant of 5 sec or less is recommended (e.g. bare thermocouple or light weight RTD).

In the sample given in Figure 9, the initial correction will initially be positive (as the temperature is above 15°C) and then becomes negative when the temperature falls below 15°C, so the net correction for this particular draw-off is 0.62Wh. Inclusion of this type of correction means that requirements for lagging and the volume of supply spurs as set out in Recommendation 25 could be more lenient as their impact will be neutralised.

Recommendation 26: A range of new requirements need to be included regarding cold water supply:

- Include a cap on the total volume of dead water in a supply spur (as per previous point)
- Include a requirement to lag supply spur pipes (as per previous point)
- Include a requirement to bleed the dead water in a supply spur within 10 min of the start of a test (as per previous point)
- Change the cold water specification so that the 15°C ± 2K applies to the supply main and any supply spur after 1 litre of water has been drawn
- Reinstate the cold water correction into IEC60436 but make sure that this applies to all water drawn into the machine as set out above (not just heated fills)
- Apply a temperature correction for the initial temperature of the load (values for each number of place settings should be calculated and included in the standard based on the average temperature of the test room for 1 hour prior to the test commencement
- Consider adding a correction for the dishwasher initial temperature at the start of the test (of the order of 0.5 Wh/place setting /K as a nominal value).

Dealing with products with on board water storage

Machine A used in the round robin has on board storage that allowed the rinse water to be stored in a tank (where this is fairly clean) and used on the next cycle. However, if the machine is not used for a certain period of time (unclear how long) or if there is a power outage (perhaps), then it appears that some of the stored water is dumped and additional fresh water is taken in the middle of the cycle. These parameters are likely to vary for different models. This feature significantly reduces water consumption and marginally reduces energy and program time in normal use, so it is a worthwhile feature. Of all the round robin tests undertaken on Machine A, only one cycle used higher water consumption (run 4 Laboratory A). The trigger for this is unclear (some gaps in testing of 20 days did not trigger the higher water use, whereas run 3 was undertaken five days before run 4 and this did trigger a stored water dump – may have been a power outage).

In a test setting, a laboratory may encounter a cycle with higher water consumption and the reason or trigger for this may not be clear or obvious. The question is how to deal with this discrepancy. In normal use in a home, a dishwasher with this feature that is used regularly is likely to have the lower water consumption most of the time. However, a dishwasher that is infrequently used may have the higher water consumption most of the time. This is also likely to be representative of the performance if there is any power outage in the home or if the power supply is intermittent.

In some respects, this is more of a consideration for regulators and what a manufacturer can claim as a water consumption value. It can also affect monitoring, verification and enforcement procedures. This type of feature is similar to regeneration of a water softener (in reverse) and the standard ignores additional water consumption associated with regeneration. However, ignoring these types of higher water consumption events in the standard is not recommended. This is not circumvention, in that the feature is likely to be active and save water and some energy during normal use (in most situations). It then becomes a matter of the test procedure identifying this different mode and documenting it. It is essential that these types of features be declared by the manufacturer, including when and how they may be activated in normal use.

It would be unlikely that dishwashers would have any electrical storage (batteries) included in the near future. However, any on-board storage (water, electricity, thermal mass) presents potential problems for all test procedures and the IEC needs to be alert to these issues.

Recommendation 27: The addition of some explanatory notes in the standard to explain that such a feature may be present, how it may work and that variations in performance may be encountered under some circumstances is recommended. The standard needs to make it clear that laboratories should measure performance parameters when these features are active and not active. The standard needs to record these modes separately where they are found to occur. Manufacturers should be required to declare the presence of such features and what impact on key parameters (energy, water) that they may have.

Microwave method and calculations

Annex F sets out the requirements for the microwave oven. There are a range of comments on this topic which are set out below.

Annex F references IEC60705 for the calculation of microwave power. It is very inconvenient to have to purchase this standard to be able to obtain the required equation. The relevant equation should be included in Annex F.

The equation was provided in a Powerpoint presentation as part of the training for the round robin (Lara Belke, 14 October 2015). There are several issues:

- The equation provided states that the energy is calculated as (T2 – T1), which is initial temperature minus final temperature. This will give a negative energy. Most likely the key to terms below is incorrect (T2 should be final temperature and T1 initial temperature, which is the more logical annotation).

- The equation provided assumes that the temperature of the water is measured and recorded before it is added to the glass bowl. This is not clear from the procedure. A more natural approach is to add the water to the glass bowl and then the measure the temperature of the bowl and water together before it is put into the microwave.
- If this approach is taken then the second term of the equation should also be changed from (T2 – T0) to (T2 – T1).
- The equation states that the specific heat capacity of the glass bowl is 0.55 J/g.K. However, the Schott glass being used for these tests is stated as 0.83 J/g.K – see the manufacturer's website http://www.schott.com/borofloat/english/attribute/thermic/

One laboratory did a range of tests on the microwave oven (noting however that the specified microwave oven in the IEC standard was not used for the round robin, but the same microwave oven was used in all Australian labs). It certainly appears that the output of the microwave oven falls off once the magnetron starts to heat up. This is potentially an issue if several soil loads are being prepared for three or four test machines and the effective power output of the oven starts to droop significantly over several hours of intermittent use. The training Powerpoint indicated that the microwave oven should rest for 12 hours prior to calibration but this is not specified in the standard. Tests at one lab showed that the supply voltage for the microwave oven also appears to have a significant effect on the microwave power, so the standard should specify that this shall be operated on a regulated power supply.

Adjustment of cleaning scores: Annex F of the standard says that cooking time should be adjusted to ensure that cleaning scores remain in the desired range. This is only possible where a laboratory is undertaking continuous testing to IEC60436 and is able to review their past results and adjust their future procedures to bring their expected results into the desired range. There should be guidance on how often and under what conditions these cooking times are adjusted. This advice was of no value for this round robin where only five tests were conducted. Labs were instructed not to adjust their cooking times for these tests (although one lab did so part way through the test series). The standard says that if the scores are too low then increase the time correction t_C. This is saying cook for longer if the score is too low (glasses are too dirty). The Powerpoint has an indirect explanation of this (longer cooking time – less milk soil stays on the glasses). This is not entirely obvious and somewhat counterintuitive, so should be clarified.

Annex F states that the target range of air dried soil is 2.9 to 3.9 for the six soiled glasses. Review of soiled glass scores from the round robin revealed considerable variation in the glass scores in the reference machine ranging from a low of around 1.0, with a second lab at 2.5 and the other three labs range from 3.2 to 4.1. Note that all labs used the same microwave oven and used the same cooking times. This suggests that there may be some variation in the cooking process and also the evaluation. This may be also due to some mixing up of the soiled and non-soiled glasses during the parallel drying and cleaning evaluation as it was not clear that these needed to be separately tracked. The target cleaning performance for the air dry method needs to be reviewed.

Edition 3 specified that glasses with milk soil are not put into the thermal oven for the oven drying method. This was always specified so as to reduce the variability of what was already a difficult to remove soil. Edition 4 of IEC60436 altered the procedure and now requires the milk soiled glasses to be dried in the thermal oven – this makes no sense as the milk soil is already completely dry and baked on at the completion of microwave cooking (no liquid remains).

More detailed calculations and information is available on request.

Recommendation 28: Several recommendations are made for consideration:

- Include the equation for calculation of microwave power in Annex F
- Clarify the procedure for establishing initial temperature in the calibration procedure (prefer that this is changed to temperature measurement of the water after it is tipped into the glass bowl)
- Correct the equation if the procedure is changed
- Correct the specific heat capacity for Schott glass in the equation
- Provide further advice on the calibration and use of the microwave, including any cooling down periods during soil preparation
- Clarify that a lower cleaning score is obtained by a shorter cooking time
- Make sure that the microwave oven is operated on a regulated power supply
- Review expected range of cleaning scores in the reference machine for air drying
- Do not put the soiled milk glasses into the thermal oven as per Edition 3.

Annex M test report format

Under rules within the IEC, technical committees are not permitted to define a test report format. This can only be undertaken by the IECEE.

Recommendation 29: Change the title of Annex M to be "Items that could be included in a test report".

Conclusions

The round robin of Australian independent accredited test laboratories showed that the underlying test method in IEC60436 is sufficiently accurate and can be applied readily in the Australian and New Zealand context. Careful review of the test procedure by laboratories and the project managers has raised a wide range of issues that have been forwarded to IEC SC59A for its consideration. Many of these are minor in nature, but some are quite significant.

A significant issue is the requirement for a test series of five runs. The requirements of IEC60436 currently conflict with the current local regulatory approach (which specifies tests across multiple samples of the same model). In the absence of any change in IEC60436, it is likely that Australia and New Zealand will modify this requirement for local application of the test procedure, as this places undue burden on suppliers. While this modification will be a significant variation from the published IEC standard, which undermines the value of regional alignment, it will have little impact on the results that are measured.

A range of other recommendations have been made to the IEC regarding refinements and improvements in the standard. It would be ideal for these to be considered and resolved within the IEC so that Australia and New Zealand can adopt the IEC test procedure without significant local variations.

The overall results from the round robin showed that the spread of results was within the band of

- ±3% Energy consumption
- ±1% Water consumption
- ±1% Cycle time

- ±3% - 5% Cleaning performance (excluding differences in performance of Type 1 and Type 2 reference machines, which is an issue that will need to be resolved)
- ±2% - 6% Drying performance (2% based on 5 runs, 6% based on a single run)

These are good test results for an electro-mechanical device whose performance and assessment is influenced by many variables including those that involve human input (e.g. soiling and evaluation processes). The spread of results are also influenced by factors including: product variability (which appeared to be fairly small); instrument and measurement uncertainty; and variations in conditions between test laboratories. This is considered to be an acceptable variability for a regulatory standard in Australia and New Zealand.

While test laboratories were generally found to have good instrumentation and procedures for calibration, some areas could be improved in terms of recording ambient conditions and verifying compliance with the requirements specified in the standard. The verification of cold water supply conditions is particularly problematic and this is an area where the IEC needs to redress the current requirements. New, clearer requirements with respect to mean conditions and permitted short term excursions have been suggested for consideration by the IEC.

The round robin has given regulators confidence that Australia and New Zealand can adopt IEC60436 for dishwasher testing as a replacement for AS/NZS2007.1. However, depending on future amendments to IEC60436 developed by IEC SC59A, a range of local variations may need to be applied in order to use this test method for energy labelling in Australia and New Zealand. Some of the issues to be considered in the application of the new test method for energy labelling have been raised in this report, but more detailed discussions with local stakeholders need to be held to identify all relevant issues prior to a transition to IEC60436 for energy labelling. The timetable for such a transition will be dictated by government in consultation with key stakeholders. In particular, the ongoing availability of a stable reference machine platform will be critical in terms of setting reliable and fair cleaning performance benchmarks.

The results of the round robin have given all parties confidence in the IEC test methodology for dishwashers and have flagged a range of issues that need to be discussed and resolved locally and considered within the IEC. The round robin has provided a solid foundation for commencing the transition process in Australia and New Zealand.

Appendix A: Dishwasher Round Robin Testing Specification: IEC60436 Edition 4

This specification was handed to participating laboratories prior to the start of testing. A modified and abbreviated version is included in this Appendix. Material that is repeated elsewhere in this report has been deleted.

Dishwasher Round Robin to IEC60436 Edition 4: Detailed Testing Specification

Prepared by EES for DEE, V2c, 5 October 2016

Overview

Introduction

The Department of the Environment and Energy (Commonwealth) is conducting a dishwasher round robin of verification test laboratories in Australia to the new IEC test method for dishwashers (IEC60436 Edition 4). The round robin will build capacity and demonstrate competency in using the IEC test methodology, with a view to adopting this as the basis for energy labelling for dishwashers in Australia and New Zealand in the future.

The round robin is covering 4 test laboratories in Australia. Energy Efficient Strategies (EES) is managing the round robin and is sub-contracting each of the participating laboratories. The Australian round robin will build on an IEC sponsored round robin that has been conducted in 2016. This document sets out the detailed testing specification for testing and the required equipment to allow test laboratories to participate.

Participating laboratories

The following test laboratories are participating in the E3 dishwasher round robin:

- SGS (Melbourne)
- VIPAC (Melbourne)
- Choice (Sydney)
- AGA (Melbourne).

The project manager is Lloyd Harrington of EES, with assistance from Robert Foster of EES.

Products to be tested

The round robin will include tests on one internationally sourced test dishwasher that is part of an international round robin organised by the IEC. The two test products are:

- Machine A – Bosch/Siemens 12 place setting dishwasher, model SN26N293EU (note the name plate has been removed and replaced with a label that says Siemens RRT2014BSH 3)
- Machine C – Miele 12 place setting dishwasher model G 4203i (note this is an Australian unit that has been substituted for the European test Machine B due to an irreparable fault).
- Reference machine Type 1 – Miele G590 (available in all labs)
- Reference machine Type 2 – Miele G1222 SC Reference (available in some labs).

All program settings and details such as detergent dose, rinse aid setting and hardness setting are set out in the sections for each dishwasher below. Loading plans are also specified for each dishwasher in the following sections. All participating laboratories have a Type 1 reference machine while 2 labs also have a Type 2 reference machine.

Test standards

Each laboratory is being supplied with a copy of IEC60436 Edition 4 in the FDIS stage (this is also the reference document used by the IEC round robin as this commenced prior to publication of Edition 4). The FDIS reference is 59A/202/FDIS (file name 59A_202e_FDIS.pdf). Testing specifications will generally be in line with IEC60436 requirements, but specific requirements for each element of the specification are set out below, particularly where there are options. Requirements that are specified in IEC60436 Edition 4 will be referenced by IEC clause number.

Test to be undertaken

Each test laboratory is being commissioned to undertake the following tests:

- 5 runs at rated capacity in accordance with IEC60436 on the test machines with combined cleaning and drying evaluation
- 5 parallel runs on one or two reference machines with combined cleaning and drying evaluation.

The tests will be in accordance with IEC60436 Edition 4 but as modified as set out in the detailed list of requirements below.

All test and reference machines have a rated capacity of 12 place settings. The majority of load items will be made up of IEC load items from AS/NZS2007.1. Where required, additional load items that are specific to Edition 4 are being supplied on loan to test labs. Details are set out in the following sections.

Description of Test Machines and Reference Machines

Machine A – Siemens SN26N293EU

This machine has a user manual which is provided in electronic form. The dishwasher has the name plate covered with a sticker that says Siemens RRT2014BSH 3. A short electronic manual is also provided as part of the round robin materials. Note that several items in this short electronic manual are not applicable to the Australian round robin, so directions in this document should be considered as definitive.

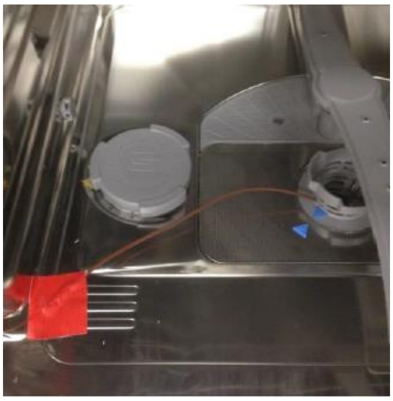
Test program: The program for all test runs (preliminary runs and full performance test runs) is the ECO 50°C program. This is clearly marked with a blue sticker that states “RRT 2014”. No other program options are to be selected (such as delay start, half load, intensive or extra drying). Program time should be about 145 minutes. The time remaining is shown on the display as the program progresses.

Rinse aid setting: This should be set to r:05 for the round robin. The short manual describes how to check the current setting and how to change this if required (the text is slightly confusing, but r:05 is the correct setting). The rinse aid reservoir should be checked at the beginning of the test series. Use only the rinse Type III rinse aid provided.

Hardness setting: For soft water tests being undertaken in Australia, the hardness setting needs to be set to H:00 (off). The short manual describes how to check the current setting and how to change this if required.

As the water softener will be off at setting H:00, salt should not be consumed by the dishwasher. However, the salt reservoir should be checked before testing commences and filled if this appears to be low. Use salt that meets the specification in the user manual, if required.

Power management setting: The dishwasher should be set so that is DOES NOT automatically disconnect at the end of the program. The power management setting should be P:00. Please check this, but it should not require changing. The manual states "P:00: Appliance does not switch off automatically. The interior light comes on when the door is opened irrespective of whether the ON/OFF switch (is switched on or off). When the door is closed the light is off. If the door is open for longer than 60 min., the light switches off automatically. The interior light is lit only when the set value is selected." (Note that the short manual states infers that P:00 is "Switching off automatically after the end of the programme" but this is not correct (this appears to be a reference to the programming option rather than the setting)).



Install a temperature sensor in the sump: Before any testing, a temperature sensor (typically a thermocouple) needs to be installed in the sump of the machine. This needs to be installed in a way that reads the water temperature during operation (please make sure this is immersed) but does not interfere with the spray arm or closing the door. The Siemens machine has no specific location for such a sensor – labs will have to use their skills to select a suitable position. Tape the wire to the floor of the dishwasher and run the sensor into the sump past the centre coarse filter as shown in the picture.

Place settings: This machine is rated at 12 place settings and all tests are done at rated capacity. The loading plan for Machine A is depicted in a separate document.

Detergent dose: All performance test runs will use 20g of IEC Detergent D (this is the dose specified in IEC60436 Edition 4 for 12 place settings). All detergent is placed in the detergent dispenser. Note that the pre-test trial runs do not have detergent. See more details below.

Please check that filters are clean at the beginning of the test series and that spray arms are operating correctly – refer to the user manual for maintenance and dealing with faults. Note that filters should not be cleaned between runs in a test series.

Note this model has a turbidity sensor that assess the clarity of the final rinse water – if this is fairly clean then it stores this water and uses it for the pre-wash on the next cycle. This will impact on the water consumption and energy consumption from run to run (water stored in the tank will be at ambient temperature = 23°C rather than 15°C if filled from mains). If the power is disconnected from the machine, it will dump the stored water when power is connected again, so try to ensure that power remains connected between tests if possible.

Machine C – Miele G 4203i

The original machine supplied for the round robin from Germany was a Miele G 6100i. However, this developed a fault at Choice before testing could begin and could not be repaired in Australia. A substitute dishwasher has been provided by Choice – Miele G 4203i. This is a similar unit to the original test machine but there are some differences and this should be called Machine C in all data recording. This specification provides details on the settings for this machine.

This machine has a user manual in electronic form.

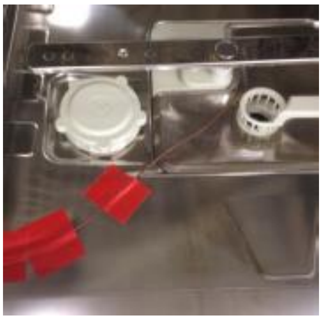
Test program: The program for all test runs (preliminary runs and full performance test runs) is the program labelled Light Soiling 50°C (fourth program down on the list of options – no words, there is a symbol with 50°C). No other program options are to be selected. Program time should be about 124 minutes. The program time is shown when the program is selected. The time remaining is shown on the display as the program progresses.

Rinse aid setting: This should be set to P3 for the round robin. The manual describes how to check the current setting and how to change this if required (p26 to p28). The rinse aid reservoir should be checked at the beginning of the test series. Use only the rinse Type III rinse aid provided.

Hardness setting: For soft water tests being undertaken in Australia, the hardness setting needs to be set to P2. The manual describes how to check the current setting and how to change this if required (p20 to p22).

As the water softener will be at a low setting, only minimal salt will be consumed by the dishwasher. However, the salt reservoir should be checked before testing commences and filled if this appears to be low. Use salt that meets the specification in the user manual if required. See manual p23 to p25.

Power management setting: The power management is called "Optimise Standby" on this machine. The factory setting is P1 = "Optimise standby" is activated. This means that the machine will revert to off mode 10 minutes after the program is complete. The full manual explains how to check this (this is the default setting so should not need to be changed). See p62.



Install a temperature sensor in the sump: Before any testing, a temperature sensor (typically a thermocouple) needs to be installed in the sump of the machine. A small hole is provided in the fine filter between the spray arm base and the coarse filter to allow a thermocouple to be inserted. This needs to be installed in a way that reads the water temperature during operation (please make sure this is immersed) but does not interfere with the spray arm or closing the door.

Place settings: This machine is rated at 14 place settings for Australia but is being treated as 12 place settings for the round robin and the full IEC load (with serving pieces). All tests are done at rated capacity. The loading plan for Machine B is depicted in a separate document. Use the loading plan depicted for the Miele G6100 I (original round robin test machine) for Machine C as the basket layout is the same.

Detergent dose: All performance test runs will use 20g of IEC Detergent D (this is the dose specified in IEC60436 Edition 4 for 12 place settings). All detergent is placed in the detergent dispenser. Note that the pre-test trial runs do not have detergent. See more details below.

Please check that filters are clean at the beginning of the test series and that spray arms are operating correctly – refer to the user manual for maintenance and dealing with faults. Note that filters should not be cleaned between runs in a test series.

Note also that Machine C is built in and will require a suitable enclosure supplied by the test laboratory in accordance. The enclosure shall comply with the dimensions specified in AS/NZS2007.1 Paragraph A16. The material of the enclosure shall be untreated plywood, chipboard or MDF with a thickness of not less than 19mm.

Type 1 Reference Machine – Miele G590

The specifications and calibration of this machine is set out in Annex E of IEC60436 Edition 3. An excerpt can be supplied on request.

Test program: For laboratories that only have a Type 1 reference, the program for all test runs (preliminary runs and full performance test runs) is the IEC reference program called Universal 65°C. No other program options are to be selected. Program time should be about 80 minutes and the cycle time is 88 min (a small fan operates for about 8 min after the program is complete). The time remaining is shown on the dial as the program progresses.

For laboratories that have both a Type 1 and Type 2 reference, the program to be selected for the first two runs is Universal 65°C and the last three runs on the AS/NZS reference program (Fein or Gentle 45°C). No other program options are to be selected. Cycle time should be about 88 minutes for the Universal 65°C programs and 103 minutes for Gentle 45°C. The time remaining is shown on the dial as the program progresses but there is not end of program signal or indicator.

Rinse aid setting: This should be set to position 2 (using the dial provided). The rinse aid reservoir should be checked at the beginning of the test series. Use only the rinse Type III rinse aid provided.

Hardness setting: For soft water tests being undertaken in Australia, the hardness setting needs to be set to 1. This is set via a dial on the door. Do not add salt to the reference dishwasher.

Install a temperature sensor in the sump: Before any testing, a temperature sensor (typically a thermocouple) needs to be installed in the sump of the machine. This needs to be installed in a way that reads the water temperature during operation (please make sure this is immersed) but does not interfere with the spray arm or closing the door.

Place settings: This machine is rated at 12 place settings and all tests are done at rated capacity. The loading plan for the Type 1 reference should be as specified in Annex I of IEC60436 Edition 4 FDIS (the basket layout is more or less the same for Type 1 and Type 2 reference machines).

Detergent dose: All laboratories will use 20g of IEC Detergent D (this is the dose specified in IEC60436 Edition 4 for 12 place settings) for all runs. All detergent is placed in the detergent dispenser. Note that the pre-test trial runs do not have detergent.

Please check that filters are clean at the beginning of the test series and that spray arms are operating correctly on the reference machines – refer to IEC60436 Edition 3 Annex E for calibration parameters. Note that filters should not be cleaned between runs in a test series. The Type 1 reference has widely spaced wires on the upper basket and care is required to ensure that small plates do not protrude down and hit or restrict the middle spray arm during operation.

Type 2 Reference Machine – Miele G1222 SC Reference

The specifications and calibration of this machine is set out in Annex I of IEC60436 Edition 4 and the FDIS of Edition 4.

Test program: The program for all test runs (preliminary runs and full performance test runs) is the IEC reference program called Reference EN/IEC. No other program options are to be selected. Program time should be about 99 minutes. The time remaining is shown on the display as the program progresses.

Rinse aid setting: This should be set to position 3 (using the electronic setting). The rinse aid reservoir should be checked at the beginning of the test series. Use only the rinse Type III rinse aid provided.

Hardness setting: For soft water tests being undertaken in Australia, the hardness setting needs to be adjusted to setting P2 (2 degrees of hardness) for soft water in Australia – refer to the manual. Do not add salt to the reference dishwasher.

Install a temperature sensor in the sump: Before any testing, a temperature sensor (typically a thermocouple) needs to be installed in the sump of the machine. This needs to be installed in a way that reads the water temperature during operation (please make sure this is immersed) but does not interfere with the spray arm or closing the door.

Place settings: This machine is rated at 12 place settings and all tests are done at rated capacity. The loading plan for the Type 2 reference is specified in Annex I of IEC60436 Edition 4 FDIS.

Detergent dose: All performance test runs will use 20g of IEC Detergent D (this is the dose specified in IEC60436 Edition 4 for 12 place settings). All detergent is placed in the detergent dispenser. Note that the pre-test trial runs do not have detergent.

Please check that filters are clean at the beginning of the test series and that spray arms are operating correctly – refer to IEC60436 Edition 4 Annex I for calibration parameters. Note that filters should not be cleaned between runs in a test series.

Reference Test Procedure

Testing will be generally in accordance with IEC60436 Edition 4. Where there are options in the IEC standard, the specific options to be used will be listed in this section. The following requirements will be specified for the Australian round robin.

Testing for the round robin will be at rated capacity (all units are 12 place settings for all tests).

Machine C is integrated, so a test enclosure will be used during the test (clause 5.1.3).

All instruments shall comply with the requirements for Annex T with respect to resolution and accuracy. Please note down any comments your laboratory may have regarding the stringency or weakness of these requirements.

Conditioning of the test machines as specified in clause 5.2 is not required as these are not new machines (noting that these runs have detergent). However, 3 pre-test runs at rated capacity for all machines (2 test machines and the reference machine(s)) is to be undertaken WITHOUT DETERGENT – see the following section on test runs to be undertaken.

Electricity supply shall be 230V ±2% and 50Hz ±1% for the reference machine(s) and the test machines as specified in clause 5.3.2. Note that clause 5.3.1 for test machines only specifies the rated voltage and frequency for testing – this is to be ignored for the Australian round robin.

Test program – this is fully specified in the previous section of this specification (see clause 5.4).

Ambient room conditions shall be 23°C ± 2K with relative humidity of 55% ±10% (clause 5.5). This includes the period for drying of the load and undertaking the tests.

Water supply to all dishwashers shall be 15°C ±2K (clause 5.6.2). Note that hot water connections are not used for these tests.

Water hardness to all dishwashers shall be “soft” (≤ 0.8 mmol/litre) (clause 5.6.3). This shall be measured on a representative sample of supply water for each test run and recorded.

Water pressure shall be 240 kPa ± 20 kPa throughout the test (clause 5.6.4). Note that this is somewhat tighter than other IEC standards as some dishwashers use timer based fills for later operations and the pressure can affect the water volume.

While the standard does not mandate data logging for these parameters throughout the test, it is a requirement for this round robin that the following parameters be recorded at 1 min intervals or more frequently throughout the test: voltage, frequency, energy (Wh), ambient air temperature, ambient humidity, water inlet temperature, water sump temperature. Water inlet pressure should be recorded if possible.

Detergent dose as per the standard (clause 5.7) using IEC Detergent D – see previous specifications. Same detergent batch to be used for all machines (supplied).

Rinse aid “III” shall be used (clause 5.8). Same rinse aid batch to be used for all machines (supplied).

Salt shall be added to the water softener and the setting shall be as recommended for soft water for each dishwasher (clause 5.9) for the test dishwashers. Ensure that the salt reservoir is filled prior to each test series. Do not add salt to the reference dishwashers.

Combined cleaning and drying performance should be undertaken, where possible. Otherwise, separate soiled runs shall be undertaken to assess drying and cleaning performance on all test machines and the reference machine(s). The contract has been costed on the basis that combined cleaning and drying evaluations will be performed.

Load items, pre-conditioning and re-conditioning shall be as per the standard (clause 6.2) – note that there are a number of melamine items and serving pieces that must be used (see Annex A and B) – see section below regarding load items.

Soiling agents and preparation shall be as per the IEC standard using specified Australian equivalent soils (the same soils to be used in all laboratories) (clause 6.3 and 6.4) (see Annex C and D) – see section below regarding soils to be used.

Loads will be air dried prior to washing (not oven dried) (clause 6.5.3). Ambient conditions must be maintained during the air drying period.

A total of 5 test runs is required for the AU round robin (note that there is NO filter cleaning between test runs).

Energy and water consumption shall be assessed as per Clause 8.

Measurement of airborne noise is NOT required.

Standby power consumption is to be measured as per Annex K (off mode, left on mode and end of cycle mode). Note that this Annex requires a meter that complies with IEC62301 and data sampling at equal intervals of 1 sec or faster. This can be undertaken at the end of any run, including the pre-test runs.

Performance Tests

Outline of Required Testing

The test procedure to be used is IEC60436 Edition 4, published in October 2015. A copy of the FDIS has been circulated as the base test method for laboratories that do not have a copy of the published standard. The FDIS includes a few small typos but this will not materially affect the round robin. This document forms the basis of the test specification for the round robin.

The Australian dishwasher round robin will include:

- 3 pre-test runs on each machine (no soil, no evaluation) , these are to be conducted to ensure that all machines are operating within specification (time, ambient, energy and water measurements only) – note that no detergent or soil is used for these runs and they should all be conducted over a day or two – see manual instructions.
- 5 parallel tests on 2 test machines plus 1 or 2 reference machines to assess cleaning and drying performance.
- Loads and soiling will be as specified in IEC60436 Edition 4.
- Combined evaluation of drying and cleaning performance to be undertaken (if the new combined evaluation procedure is not undertaken, then separate soiled runs for washing and drying evaluation will need to be undertaken)
- Evaluation of standby power.

Laboratories will be required to prepare brief summary reports containing their test results. Key performance data and results will be entered into a spreadsheet provided. Raw test data for energy, water consumption and temperatures is to be logged and provided in electronic format to all independent review afterwards. Laboratories will be required to answer a questionnaire relating to how tests were conducted and the experience of the test laboratory. Laboratories should note any issues that require clarification or parts of the standard that could be clearer as they progress. Formal NATA test reports will not be required. Data from each laboratory may be shared internationally as part of the IEC round robin, but with laboratories de-identified. Laboratories will have access to Australia's comparative data for use in helping satisfy NATA proficiency test requirements.

Load items

Load items will generally be in accordance with Annex A and Annex B of IEC60436 Edition 4. All dishwashers (2 test machines, Type 1 reference, Type 2 reference) are all rated at 12 place settings for this round robin, so 36 or 48 place settings will be required, depending on the lab. The total number of load items by type is set out in Edition 4 in Table A.2. The total number of load items for 12 place settings in 130 for each machine.

The following table sets out the load items specified in Edition 4, the number of items required and the source of each item for the round robin for each test machine and each reference machine. IEC item numbers are as set out in Edition 4 Annex A and Annex B. Item numbers noted in the comment column of Table 24 are as specified in IEC60436 Edition 3 Table A.2 and AS/NZS2007.1-2005 Table A3. Edition 4 Items A1, A2, A5/B5, B1, B3 and B4 are the same as items specified in Edition 3 and AS/NZS2007.1-2005 (but with difference references). Edition 4 splits the load into two halves (to facilitate half load testing), so some items with A and B references are in fact the same item.

Table 24: List of load items in a single 12 place setting test machine

IEC item	Description	No.	Comment
A1	Dinner plate	6	Same as Edition 3 item 1
A2	Dessert plate	6	Same as Edition 3 item 3
A3	Dessert bowl	6	New in Edition 4
A4	Mug	6	New in Edition 4
A5 (B5)	Glass	12	Same as Edition 3 item 6
A6 (B6)	Fork	12	Edition 4 new model but Edition 3 equivalent
A7 (B7)	Knife	12	Edition 4 new model but Edition 3 equivalent
A8 (B8)	Soup spoon	12	Edition 4 new model but Edition 3 equivalent
A9 (B9)	Dessert spoon	12	Edition 4 new model but Edition 3 equivalent
A10 (B10)	Tea spoon	12	Edition 4 new model but Edition 3 equivalent
B1	Soup plate	6	Same as Edition 3 item 2
B2	Dessert plate Melamine	6	New in Edition 4
B3	Saucer	6	Same as Edition 3 item 5
B4	Cup	6	Same as Edition 3 item 4
S1a	Small pot	1	New in Edition 4
S1b	Oven pot	1	New in Edition 4

IEC item	Description	No.	Comment
S2	Glass bowl	1	New in Edition 4
S3	Oval platter	1	New in Edition 4
S4	Melamine bowl	2	New in Edition 4
S5	Serving spoon	2	New in Edition 4
S6	Serving fork	1	New in Edition 4
S7	Ladle	1	New in Edition 4
	Total items	130	

Notes: Cutlery and glasses are split into A and B item numbers to allow half load specification, but each is the same.

Items marked as New in Edition 4 will be supplied to test laboratories where required (sufficient new items have been purchased from WfK in Germany for one laboratory and 48 place settings). Cutlery in Edition 4 is a new model from the same manufacturer (WMF) but the model specified in Edition 4 was selected to be as close as possible to the previous model specified in IEC Edition 3 and AS/NZS ("Berlin") as this was no longer manufactured. For the round robin, test laboratories should use cutlery specified in AS/NZS and IEC60436 Edition 3.

Pre-testing

Prior to conducting any performance tests, specified pretesting is to be undertaken on the test dishwashers and the reference dishwasher(s). These tests are to be conducted as follows:

- Install the dishwasher in the test laboratory with logging equipment connected
- Load at rated capacity with a clean load, NO DETERGENT, loaded as per the loading plan for each unit
- Select the reference or test program and operate
- Data log all parameters such as energy, water, time, water temperature, air temperature, sump temperature, relative humidity, water pressure and record the average or total values of these for each run in the spreadsheet provided (water and temperature is required separately for the main wash and the final rinse)
- All three runs could be conducted in a single day or over two days. Machine A has a program called Pre-rinse and the Type 1 reference has a Pre-wash program. These can be used to cool down the load between runs to allow less time between pre-testing runs. For Machine C and the Type 2 reference machine, there is no suitable program to cool the load so the machine has to be left for >2 hours with the drawers open to cool between runs.
- Record all data in the pre-test spreadsheet provided – send this to the program manager and the IEC contact and await approval before proceeding to full performance tests.

Performance tests

Detergent and rinse aid

Detergent D and Rinse Aid III as specified in IEC60436 Edition 4 shall be used for the tests. Detergent and rinse aid will be provided for the round robin.

List of soils to be used in the round robin

For the Australian Round Robin, a list of specific soils is specified for use in testing. Most of these are available from major supermarkets, so this means that all laboratories will be using soil items that are virtually the same at the time of the round robin.

Milk

Devondale semi-skim UHT milk. 1 litre is recommended (2 litre is shown).

Tea

Twinings Ceylon Orange Pekoe loose tea (Note: If this product cannot be procured then stocks available from VIPAC may be used)

Minced Meat

Select Beef Topside Roast.

Eggs

Any free range hens eggs from 50g to 65g per egg. Note that these must be >7 days old.

Oat Flakes

Lowan whole grain quick oats

Spinach

Birds Eye chopped spinach – all natural. These packs are 450g.

Margarine

Flora Original made with sunflower seed oil.

Soiling

Soils are to be prepared in accordance with Clause 6.3 of IEC60436 Edition 4.

A training workshop was held in Melbourne on 26 September 2016 to provide guidance to participating Melbourne labs prior to testing.

Special equipment

IEC60436 Edition 4 requires several pieces of specialised equipment for the preparation of soils. These are:

- Microwave oven for the preparation of milk soils – a suitable microwave oven has been purchased and this will travel to each test laboratory with the test dishwashers. The calibration procedure needs to be untaken by each laboratory prior to initial use. Homemaker 20 litre EM720CWW(F). Before commencing any performance testing the calibration results on the microwave need to be forwarded to the project manager, who will review the results and agree suitable duration periods for the microwaving process applied to the milk soils.

- Glass bowl for calibrating the microwave oven – a suitable bowl will be provided with the dishwasher. A suitable Schott bowl is on loan to the Melbourne laboratories from Choice. If you break it you will need to replace it.
- Grinder – a grinder with selected plates needs to be used to prepare meat and spinach as part of the soiling process. A suitable grinder (Sunbeam FG5600) has been purchased and this will travel to each test laboratory with the test dishwashers. The plate supplied with the grinder with 4.5mm holes is suitable for the meat. A specially made plate for the spinach with 2mm holes is on loan from AGA for the round robin.

The microwave calibration procedure is somewhat complex and there may be small errors in the standard. A detailed description of the process and an Excel worksheet is being provided to assist laboratories learn this process. See the training materials.

Air drying

Once soiling is completed, the load shall be spread out to air dry for 15 to 18 hours in the specified laboratory ambient conditions (temperature and humidity) in accordance with Clause 6.5.3. Note that an oven is NOT used to dry the load.

Load placement and stacking

Loading plans are provided for each dishwasher at rated capacity. These loading plans shall be followed exactly when loading the soiled load items prior to a performance assessment. Note: To accommodate the 2 melamine serving bowls (S4) in the G590 reference machine whilst ensuring that they do not touch each other, the adjacent pots will need to be moved across slightly such that there are two tines between the first and second bowls – see picture below:

Combined cleaning and drying evaluation

Edition 3 required separate soiled loads for drying and cleaning evaluation. The concern is that using a clean load for assessing drying performance would allow suppliers to sense whether there was any soil present and truncate the program (or boost dryer heating) in cases where there was no soil present. Sensing programs in dishwashers are relatively common these days and many use turbidity sensors to decide whether the save rinse water for the next test run.

Edition 4 has the same requirement but allows the cleaning and drying evaluation to be conducted in a single test run. This potentially reduces the number of runs that need to be undertaken when doing a full performance evaluation. However, it does present some logistical challenges for test laboratories. Drying evaluation is time critical as the load is hot at the end of the program and water quickly evaporates. Edition 4 requires that drying evaluation be commenced 30 minutes after the completion of the cycle (NOT program) and that all items are evaluated in an average time of 8 sec per item, which includes a 3 sec viewing time for evaluation. Once assessed, items then need to be stacked for a later cleaning evaluation, taking care not to disturb any soil that may be present. For these test dishwashers, this means that drying evaluation must be completed in 130 x 8 secs = 1040 sec = 17 min 20 sec from the opening of the dishwasher door (the total time is 17 min and 34 sec when you take the longer time allowed for pots into account). You should aim to complete your evaluation in this amount of time (not significantly faster or slower). Drying evaluation and scoring is the same as Edition 3 and AS/NZS2007.1. However, there is one notable exception, where the two pots are evaluated as if they were four separate items:

> *Evaluate for each pot, the drying of the inner bottom, the inner wall and the outer surfaces individually. Additionally give one score over the entire pot. This leads to a total number of four scores per pot. Do not include the pot handles in the evaluation.*

The scoring spreadsheet records the overall score first then the inner base, then inner walls then outside for each pot. The four single scores for each pot shall not take longer than 15 sec (9 sec handling + 6 sec viewing).

Cleaning evaluation is assessed for 10 sec per item. There is no specific time limit on cleaning evaluation. Cleaning evaluation and scoring is the same as Edition 3 and AS/NZS2007.1. Cleaning evaluation is likely to take about 35 minutes for each machine. Similarly, the only notable difference is the scoring of the pots, which are treated as four separate items.

> *Evaluate for each pot the cleaning of the inner bottom, the inner wall and the outer surfaces individually. Additionally give one score over the entire pot. This leads to a total number of four scores per pot.*

The evaluation of the four single pot scores for each pot shall not take longer than 30 sec.

All evaluation shall be conducted in a light box or where general lighting meets the requirements of 1000 lux to 1500 lux and a colour temperature of 3500K to 4500K as per Clause 7.1. A light box is preferable for consistent evaluation.

The strategic planning required by laboratories is that test and reference dishwashers need to be staggered in their start times to allow sufficient time to complete the drying evaluation and get organised to undertake the drying evaluation in the next machine within the allowable times. This is why knowing the program time is critical. Two possible approaches could be taken by labs:

- Option 1: Stagger the dishwashers to finish about 30 min apart so that a drying evaluation can be completed on each machine in sequence. The cleaning evaluation can be done for all 4 machines later in the day or alternatively the cleaning evaluation can be undertaken immediately after the drying performance using a second assessor. Where a separate assessor is used for washing and drying, the drying assessor must evaluate all machines for all tests and the washing assessor must evaluation all machines all tests. This option with either one or two assessors seems to be a very workable option.
- Option 2: Stagger the dishwashers to finish about 1:05 apart so that a drying evaluation and then a cleaning evaluation can be conducted on each machine before moving to the next machine. This may be preferable in cases where there is limited space to spread all the loads out after drying evaluation of all dishwashers. However, technically the reference machine and all the test machines have at least part of their cycle running at the same time in order to be valid (this is quite hard to organise with 3 or more test machines and may be a point on which we comment to IEC). Clause 6.6.2 states: "However, test machines shall run at the same time as part of the reference machine cycle."

Note that loads can be put back into the dishwasher after drying evaluation and before cleaning evaluation, but care is needed to ensure that no soil falls off load items in the process.

Standby Power

Standby power needs to be determined in accordance with Annex K. Left on, end of cycle and off mode shall be determined. For left on mode and end of cycle modes, data at the end of a program needs to be recorded at 1 sec intervals for around 30 min in order to obtain sufficient data. Meters should comply with IEC62301. These measurements can be undertaken at the end of any selected program with or without a load (soiled or unsoiled) and with or without detergent. This could be at the end of the pre-trial test runs, at the end of the main test runs[4] or at the end of any additional runs undertaken for the sole purpose of measuring standby power. As an option, the power consumption of delay start mode may also be measured and recorded by test laboratories. Details are set out in the training presentation.

Recording Results

All results need to be recorded in the Excel spreadsheets provided. The three main sheets to be filled in are:

- Pre-test trial runs
- Main data input sheet – this includes detailed drying and cleaning data by item for each run, energy and water consumption, temperatures, standby power
- Laboratory questionnaire – you should complete this before you start serious testing.

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[4] Note that many digital power analysers when recording data cannot auto-range, so this means that recording would have to be stopped at the end of the cycle in order to select the correct current range for standby power measurements. This may invalidate the main run unless care is taken. Power analysers should be configured to "low power mode" wiring when performing standby measurements.

Raw data logs (1 min intervals) should be supplied to EES in electronic form for independent evaluation. This should include energy, water and all relevant temperatures.

See information at the end about naming files.

Laboratories should keep notes about any issues that are unclear in the standard, issues that require clarification or refinement and about requirements that are difficult to meet or that could be improved. These should be compiled during testing and submitted to EES at the completion of testing. These issues will be discussed at the workshop and consolidated for submission to IEC.

Logistics

EES is the program manager for this work and any questions should be directed to Lloyd Harrington or Robert Foster. Laboratories have a maximum of 15 working days to install the dishwashers, complete all testing and have then have the test machines ready to ship to the next destination. The test dishwashers are provided with special packing crates – these must be retained and reused when shipping to the next destination. EES will cover the cost of shipping, but test labs will need to closely liaise with the transport company to ensure smooth delivery and pickup. EES will nominate a preferred transport company.

Additional load items (in addition to AS/NZS2007.1) and special equipment are being provided to Melbourne labs and moved with the dishwashers (it may be necessary to transport these separately to the dishwashers themselves). Melbourne labs are welcome to bid for the purchase of these load items and equipment at the end of testing in Melbourne.

A training day was held on 26 September 2016 at AGA. A range of training materials were presented and well as a practical demonstration of soiling. Labs have been sent all training materials and powerpoints by email.

List of documents cited by this specification

IEC60436: Electric dishwashers for household use – Methods for measuring the performance, Edition 4, October 2015.

59A/202/FDIS: Electric dishwashers for household use – Methods for measuring the performance, FDIS English, 25 September 2015, file 59A_202e_FDIS.pdf Note that there are some small typo errors in the FDIS regarding part numbers for some load items, but this is of no consequence for the Australian round robin.

IEC60436: Electric dishwashers for household use – Methods for measuring the performance, Edition 3, February 2004. (also Amendment 1: 2009 and Amendment 2: 2012).

Load plan Machine A – file IEC_RRT_DW15_LoadingScheme_MachineA-full.pdf

Load plan   – file IEC_RRT_DW15_LoadingScheme_MachineB-full.pdf (note that this is for the G 6100i but the same basket layout applies to the G 4203i)

Short Manual Machine A: file Short Manual Machine A (BSH).pdf

~~Short Manual Machine B: file Short Manual Machine B (Miele).pdf~~ (not applicable now)

Full Manual Machine A: file Manual_MachineA.pdf

Full Manual Machine C: file Manual-AU-MachineC-Miele-G4203i.pdf

Data Recording Sheets

Pre-test data sheet - Excel

Round Robin data input sheets – Excel (one for each test machine)

Round Robin Questionnaire - Excel

Microwave calibration Excel sheet (for laboratory use only – does not need to be submitted)

Labs are being allocated nominal identifiers for all test results and recording of data (called a LabID). This is a 2 letter random code. Please contact Lloyd or Robert to get the code for your laboratory.

Naming of data recording sheets shall be as follows:

IEC_RRT_DW15_Pretest-LabID.xls

IEC_RRT_DW15_Questionnaire-LabID.xls

IEC_RRT_DW15_Data_Input-LabID-MachineID.xls (one for each test machine, two or three files for each lab)

For the data input recording sheet, you need to save a separate copy of the input sheet for each test machine (Machine A, Machine C, and for AGA/Choice treat the Type 1 reference as a test machine). Once reference machine data has been entered into the sheet for the first test machine, you can copy this data into reference data section for each of the other test machines that were run in parallel. Protection has been removed from cells Q23 to C174. Be careful not to include any input into the coloured rows (e.g. 34, 41, 48 etc.).

Note that there are 136 entries for drying and cleaning performance. There are 130 items, but the two pots are allocated four scores each – the first is an overall score, then the inner base, the inner walls and the outside each has a separate cleaning and drying score.

An additional sheet called Item-list has been added – this includes the IEC item IDs to assist in identification as you evaluate. The IEC codes have now been included in the Drying and Cleaning sheets for each reference. It is a good idea to have examples of each load item next to the evaluation labelled with the correct code to assist with entering scores as some of the names for some items are quite similar and some of the items are a similar size.

Materials sent by email

A total of 3 emails have been sent to each laboratory. Attachments are as follows:

Email 1: Training.zip – this includes all powerpoints and microwave worksheets (8 files)

Email 2: Manuals.zip – this includes electronic manuals for test dishwashers, loading plans and a copy of IEC60436 Edition 4 FDIS (7 files)

Email 3: Includes the following files:

- IEC_RRT_DW15_Pretest-LabID.xls
- IEC_RRT_DW15_Questionnaire-LabID.xls
- IEC_RRT_DW15_Data_Input-LabID-MachineID.xls
- Dishwasher Round Robin to IEC60436 Ed4 - specification V02a.docx (this document)

END OF SPECIFICATION

Appendix B: Selected plots of raw data

Peak power discussion: Peak power seems to be consistently recorded across labs. Small variations in measured values in some labs due to sequence of heater operation and pumps. All labs had high quality power measurement instruments. These figures illustrate that the reference and test machines are operating very consistently.

Figure 10: Maximum power comparison across laboratories for Machine A

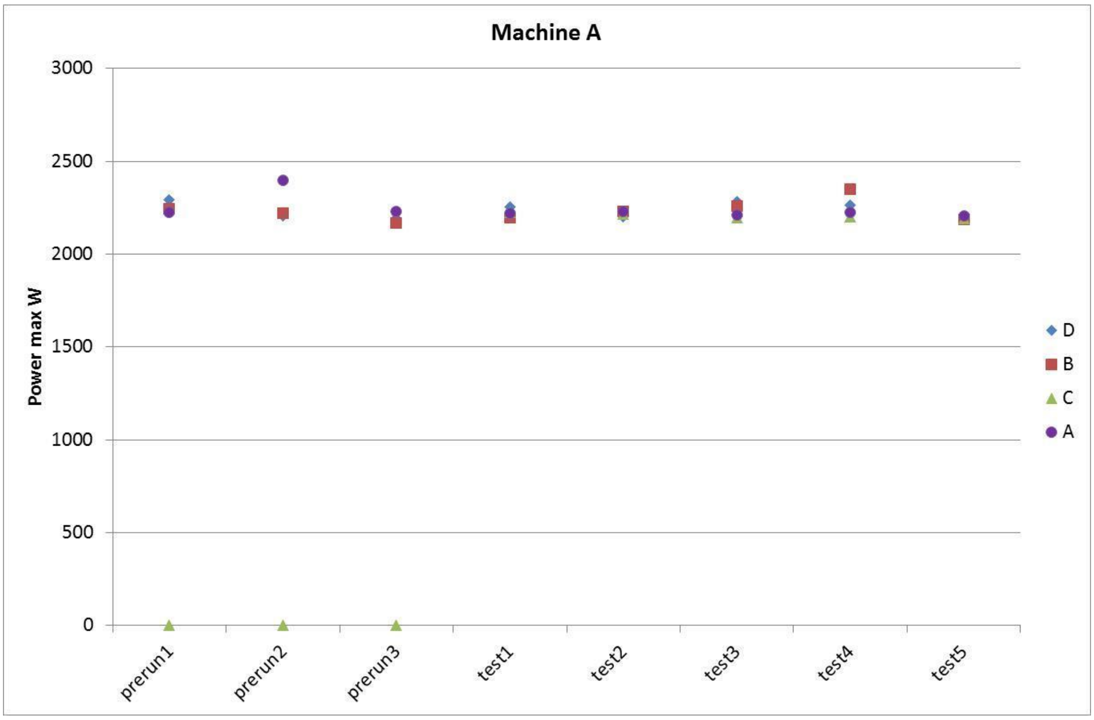


Figure 11: Maximum power comparison across laboratories for Machine C

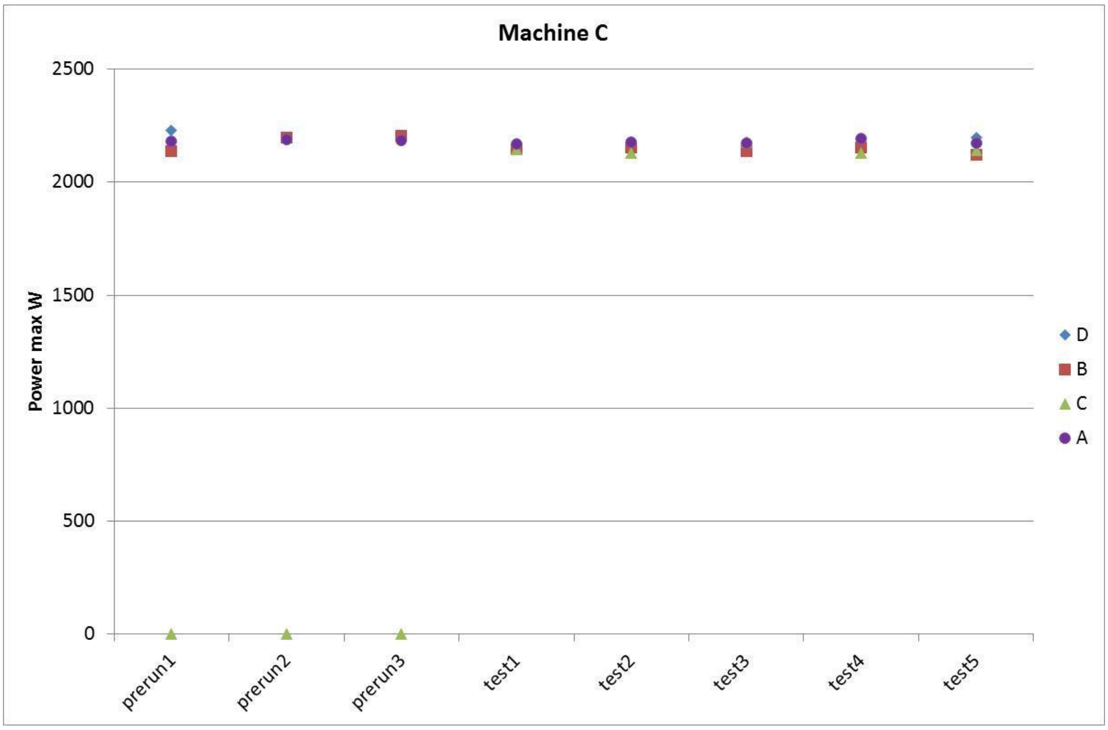


Figure 12: Maximum power comparison across laboratories for Type 1 Reference Universal 65 program

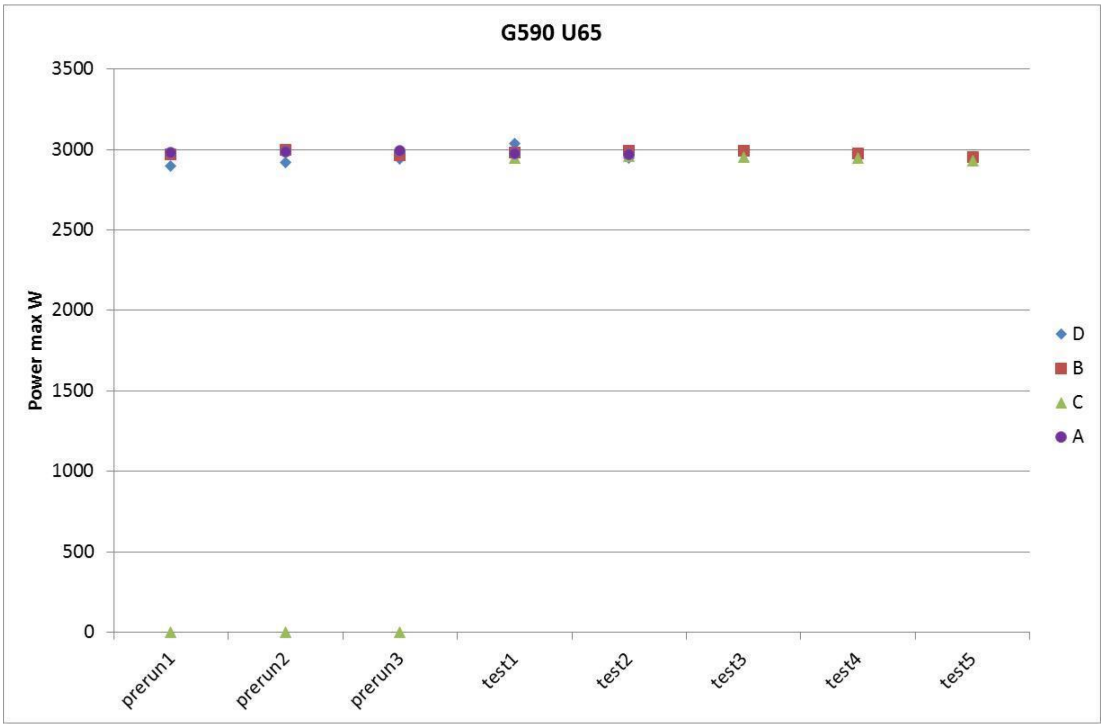
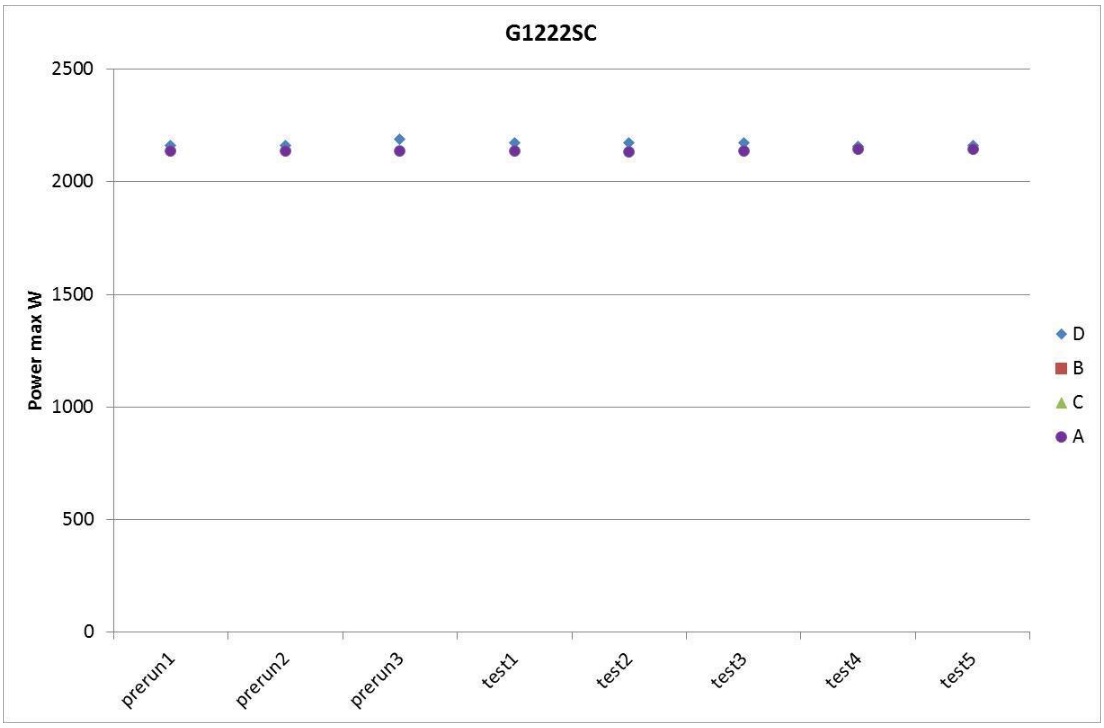


Figure 13: Maximum power comparison across laboratories for Type 2 Reference IEC/EN ref program



Wash and rinse temperature discussion: Some labs had issues measuring bath temperatures on occasions. Some units seem to generate electrical noise which can affect bare thermocouples. These figures illustrate that the reference and test machines are operating very consistently. Measurement of bath temperature provides some additional information about machine behaviour.

Figure 14: Maximum wash temperature across laboratories for Machine A

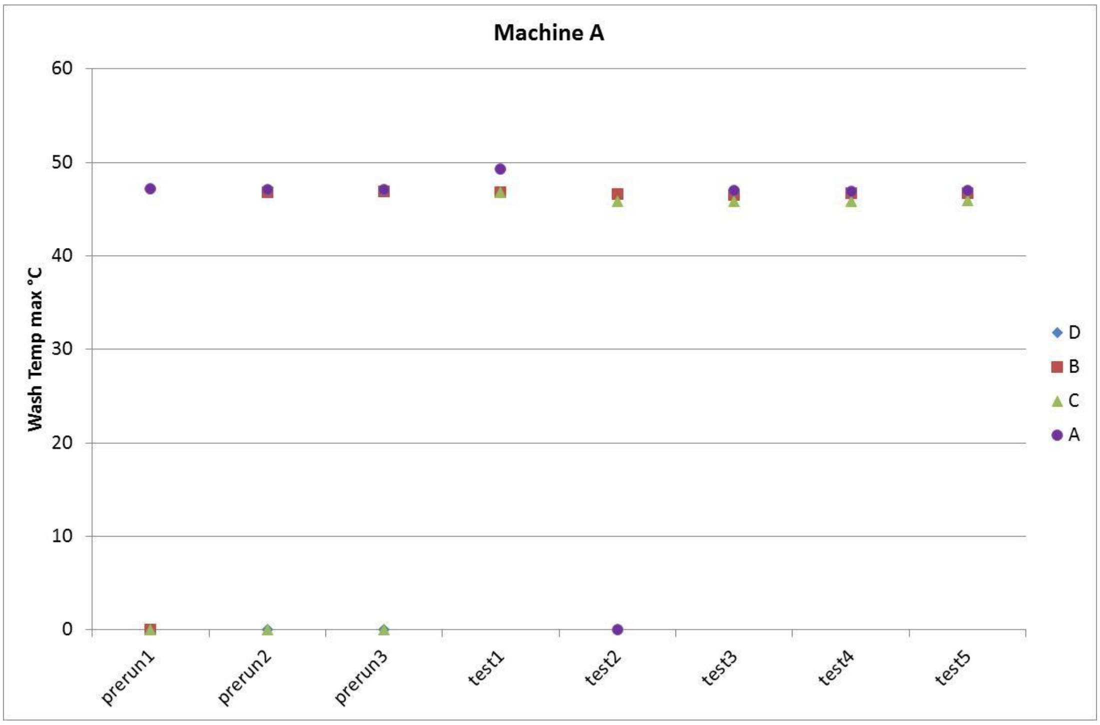
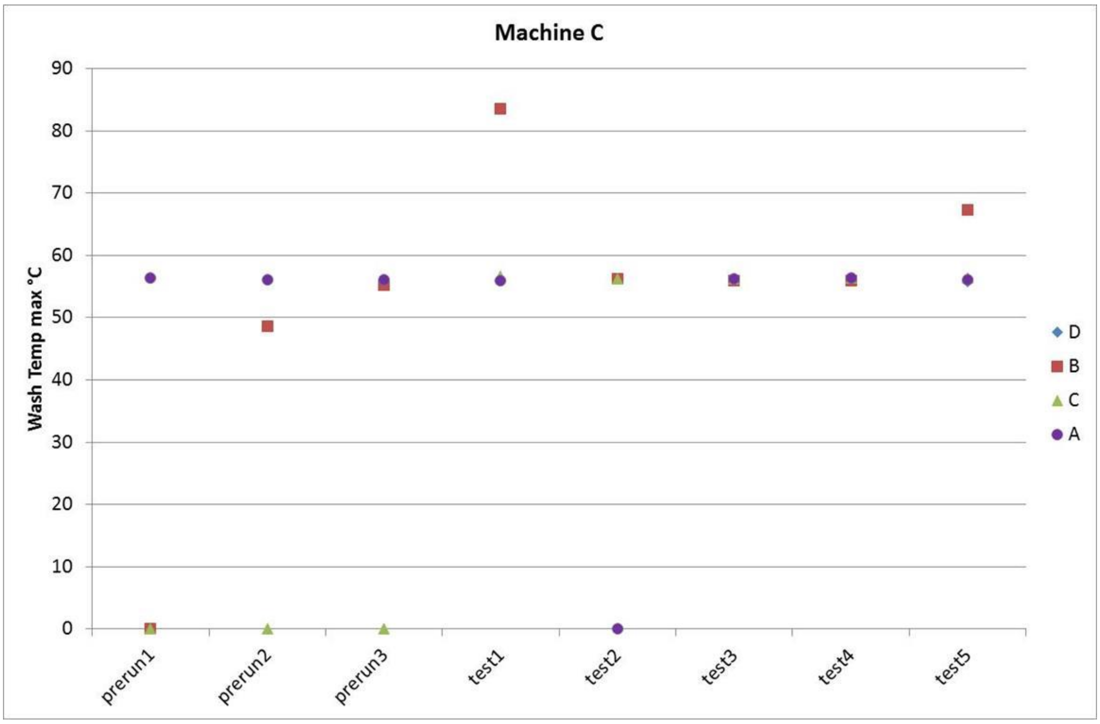
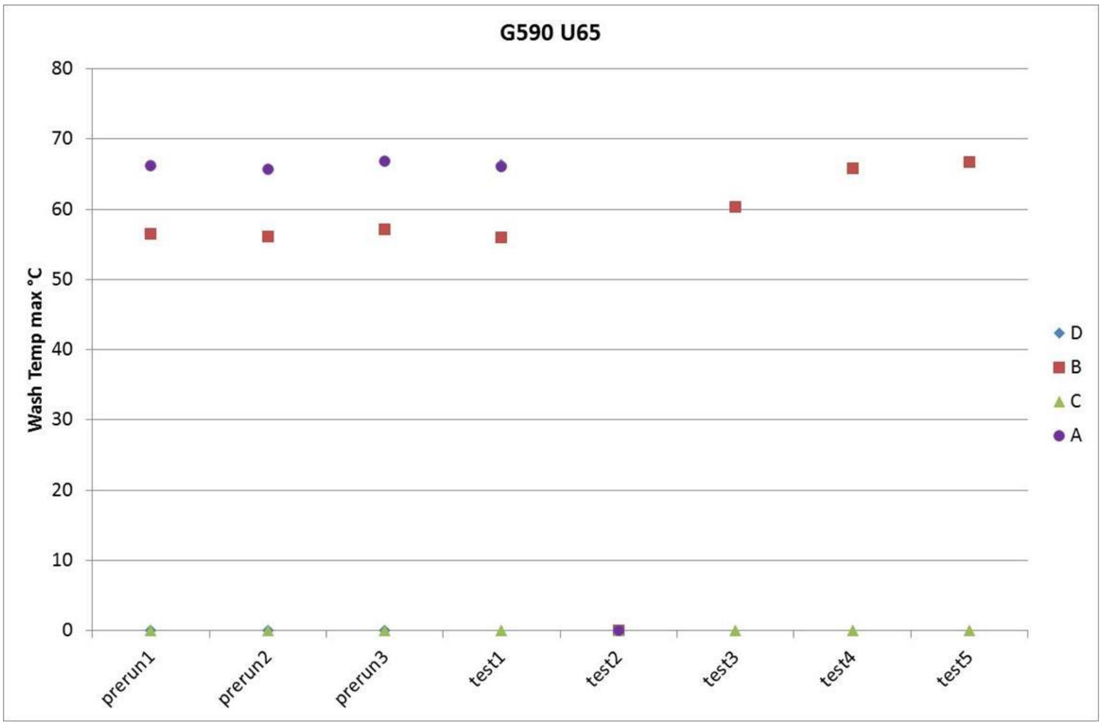


Figure 15: Maximum wash temperature across laboratories for Machine C



Note: Lab B had technical problems with their thermocouple for some tests

Figure 16: Maximum wash temperature across laboratories for Type 1 Reference



Note: Lab B had technical problems with their thermocouple for most tests

Figure 17: Maximum wash temperature across laboratories for Type 2 Reference

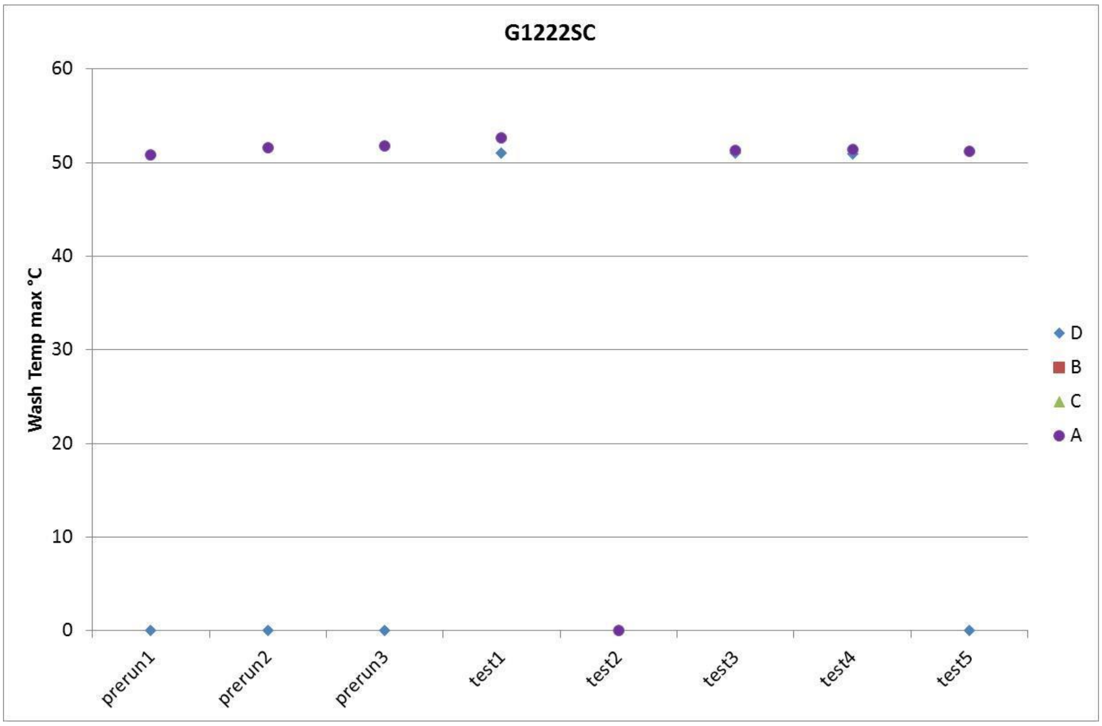


Figure 18: Maximum final rinse temperature across laboratories for Machine A

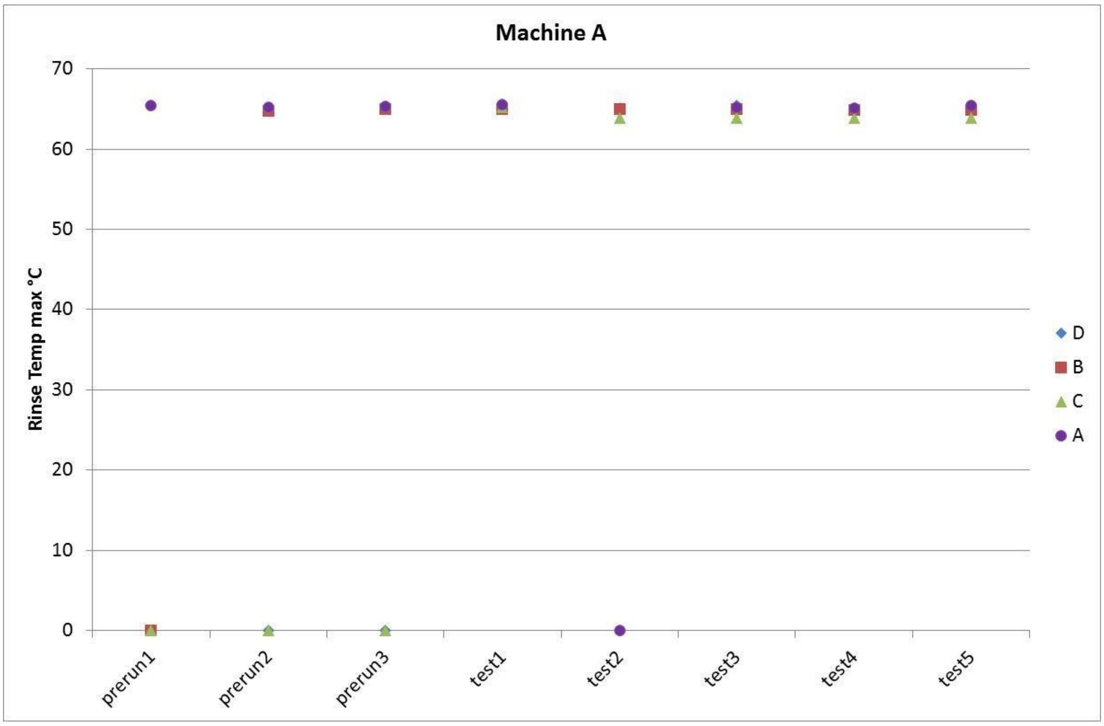
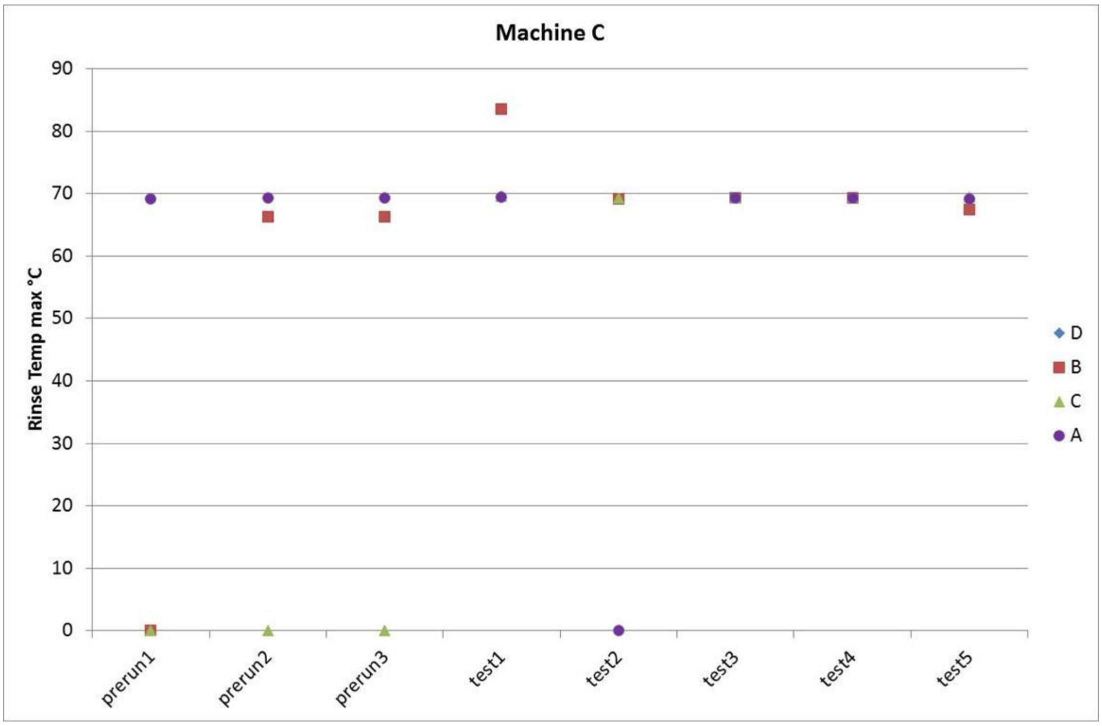
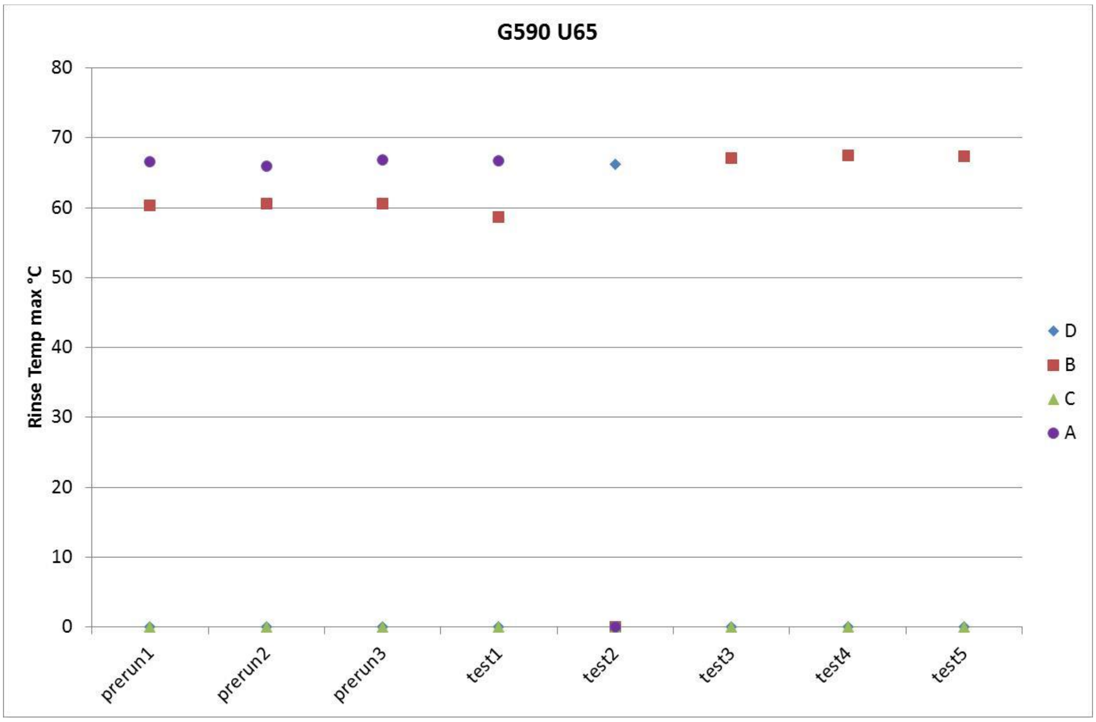


Figure 19: Maximum final rinse temperature across laboratories for Machine C



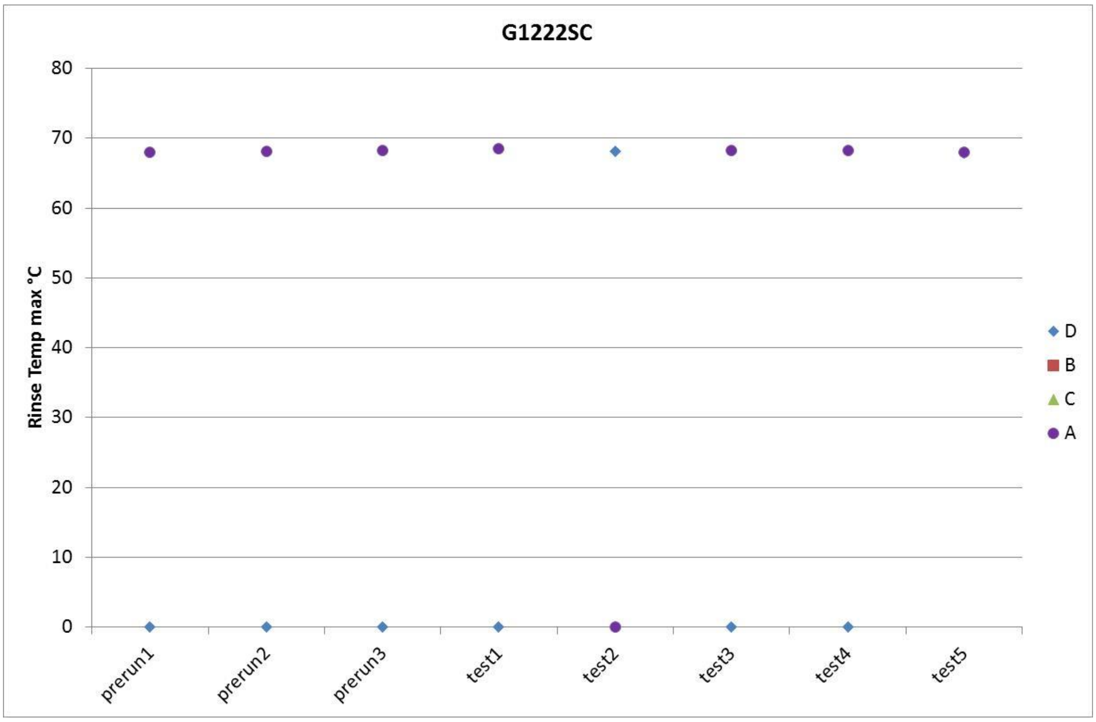
Note: Lab B had technical problems with their thermocouple for some tests

Figure 20: Maximum final rinse temperature across laboratories for Type 1 reference



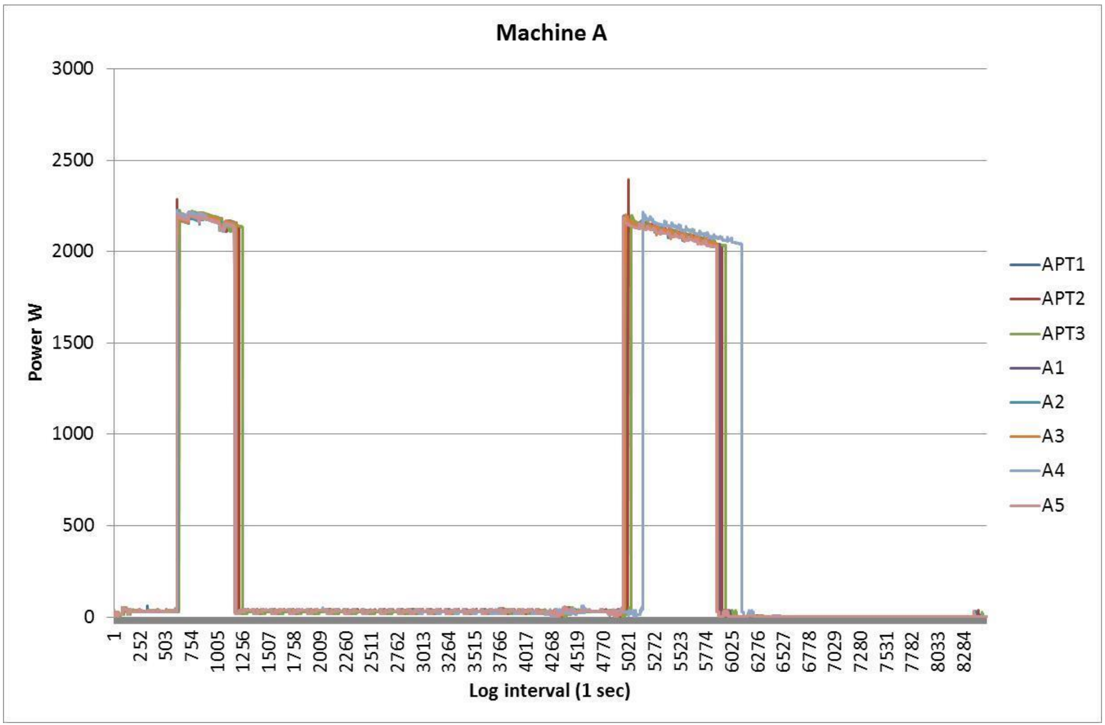
Note: Lab B had technical problems with their thermocouple for some tests

Figure 21: Maximum final rinse temperature across laboratories for Type 2 reference



Power profile discussion: Data on power profiles across all runs in each lab could be compared for consistency. Test machines appear to be operating in a very consistent manner in each lab.

Figure 22: Power profiles for all runs in Laboratory A for Machine A



Note: Run A4 had additional water intake.

Figure 23: Power profiles for all runs in Laboratory B for Machine A

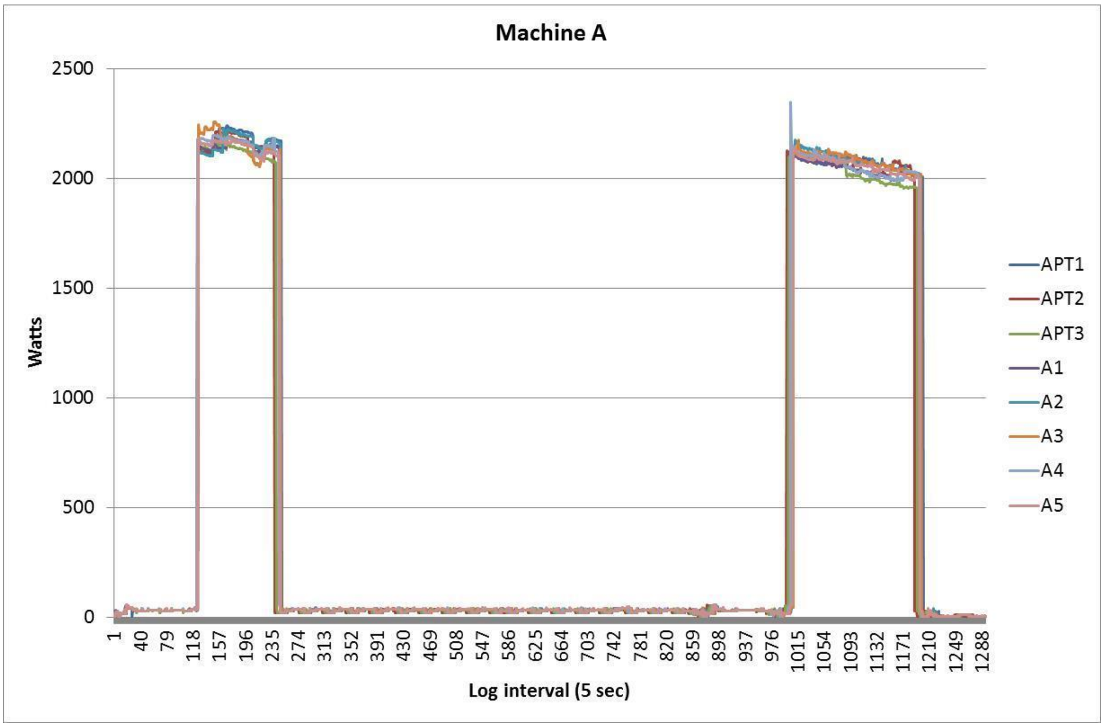
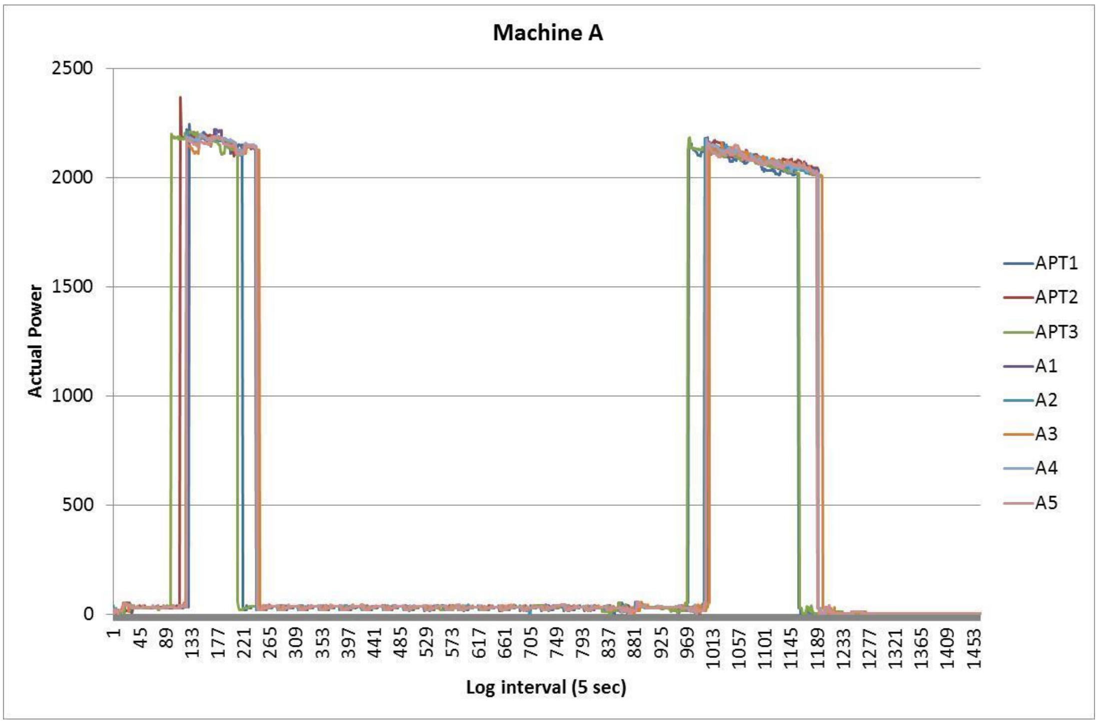


Figure 24: Power profiles for all runs in Laboratory C for Machine A



Note: Some variation in cold water temperature may be influencing profile

Figure 25: Power profiles for all runs in Laboratory D for Machine A

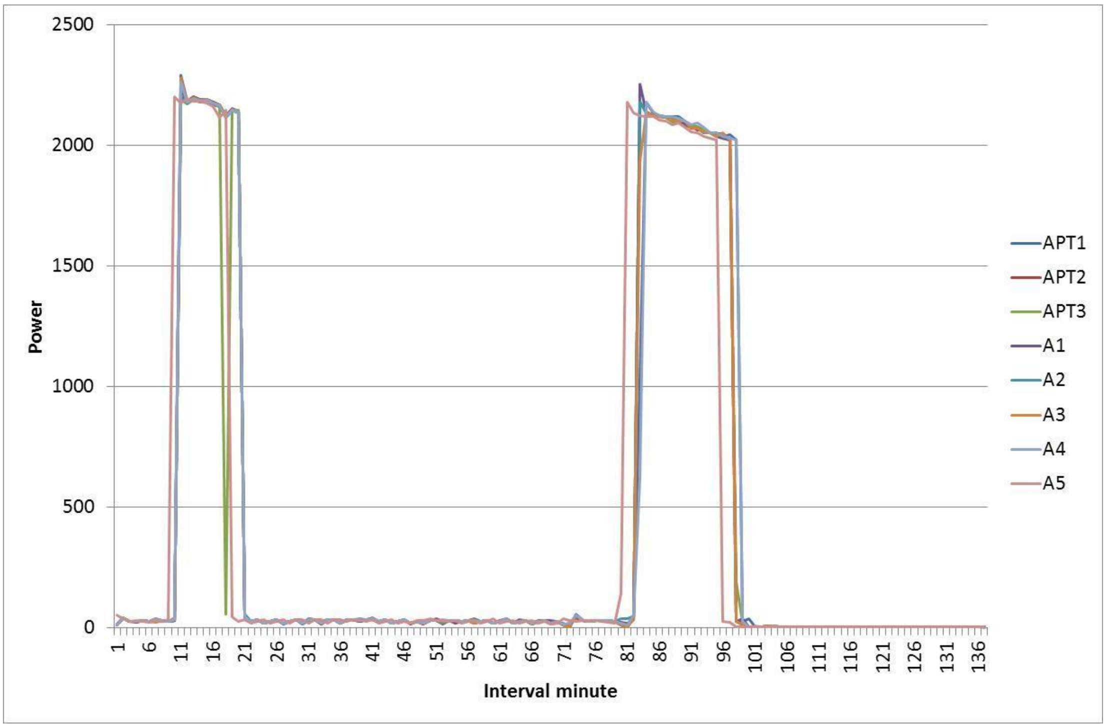
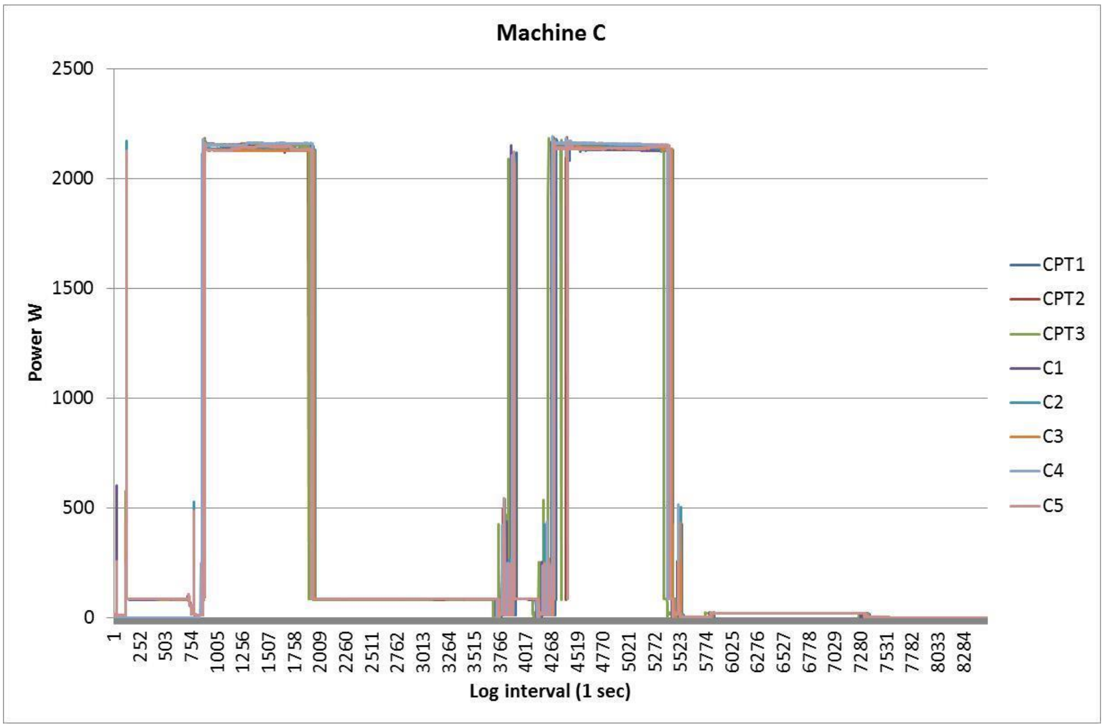


Figure 26: Power profiles for all runs in Laboratory A for Machine C



Note: Some heating prior to final rinse on all runs

Figure 27: Power profiles for all runs in Laboratory B for Machine C

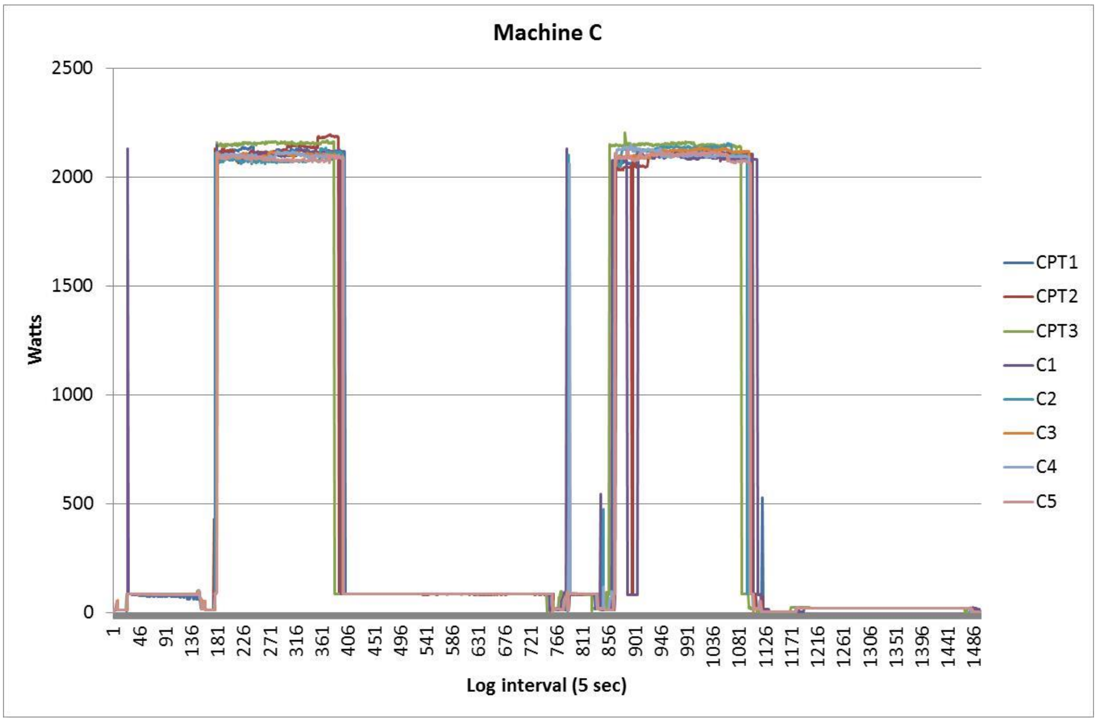


Figure 28: Power profiles for all runs in Laboratory C for Machine C

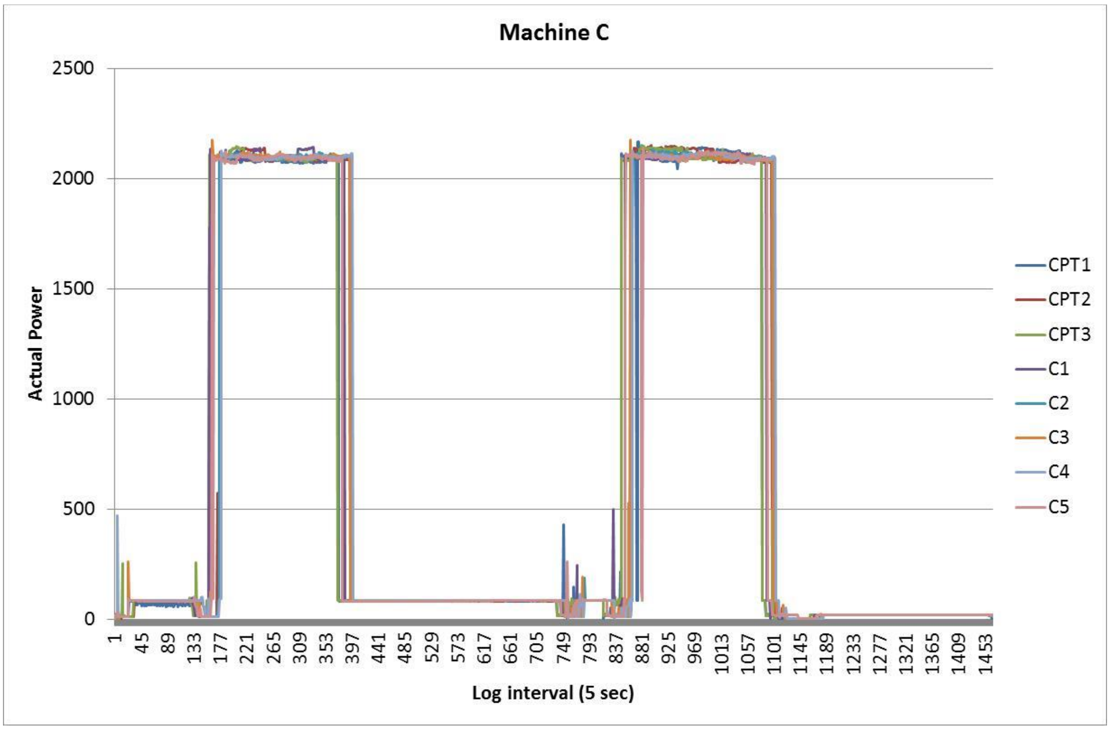
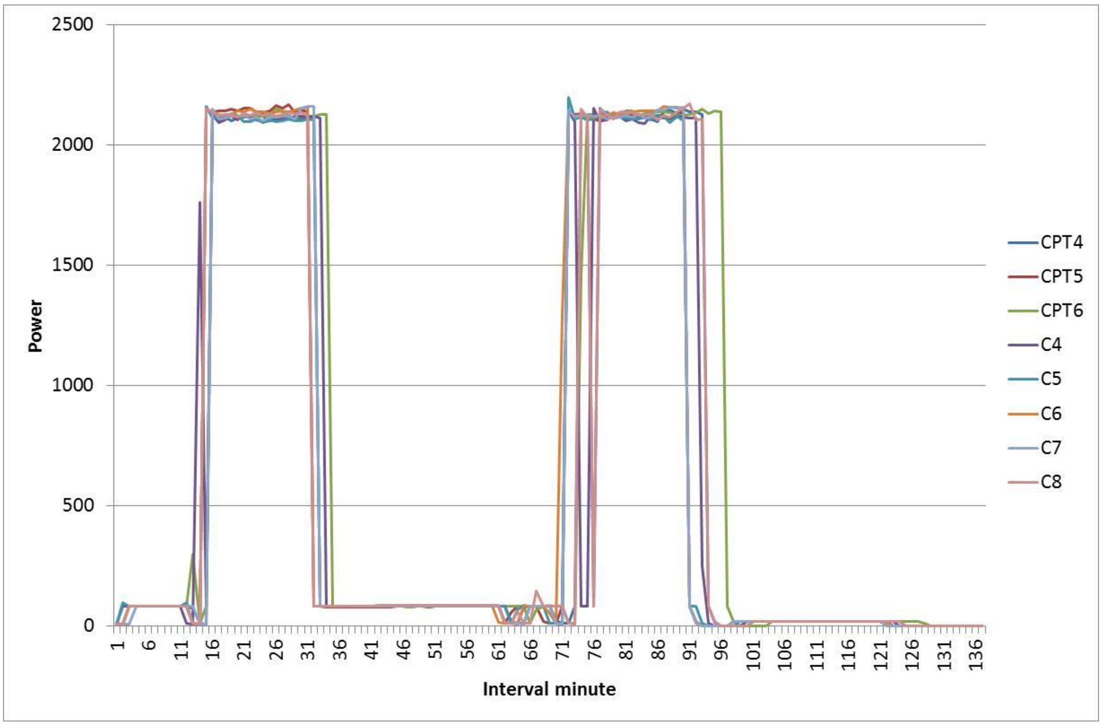
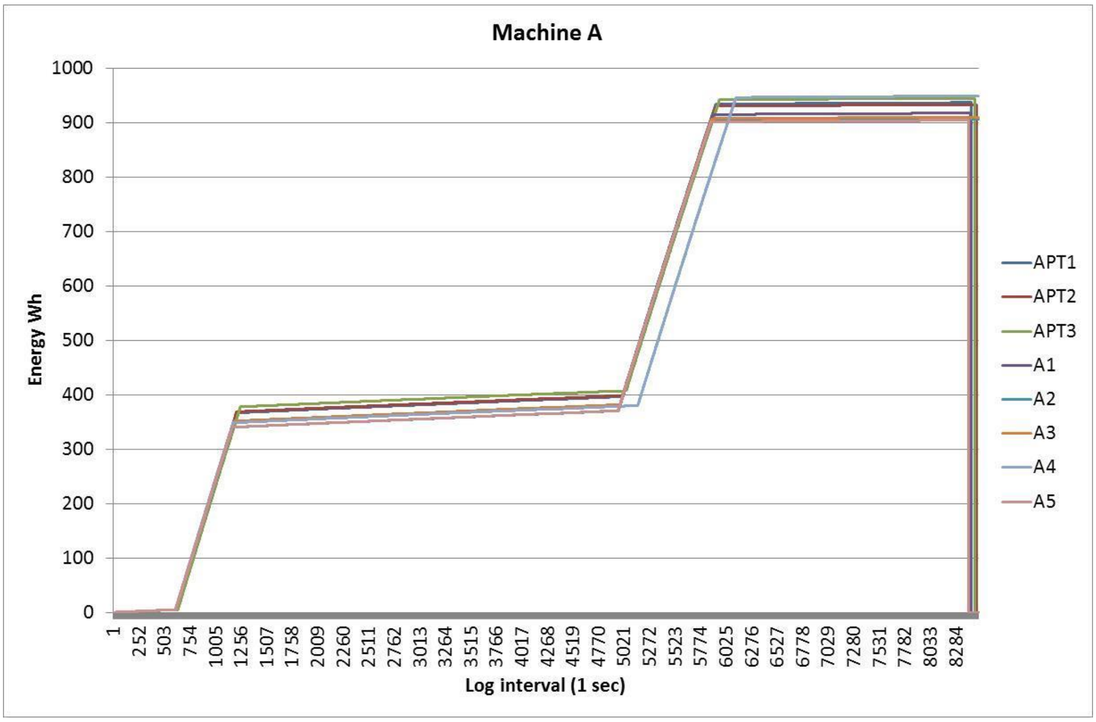


Figure 29: Power profiles for all runs in Laboratory D for Machine C



Energy discussion: Data on energy consumed across all runs in each lab could be compared for consistency. Test machines appear to be operating in a consistent manner in each lab, although run to run variation is up to 2%. Run 4 on Machine A used additional water and hence more energy.

Figure 30: Energy profiles for all runs in Laboratory A for Machine A



Note: Run A4 had additional water intake.

Figure 31: Energy profiles for all runs in Laboratory B for Machine A

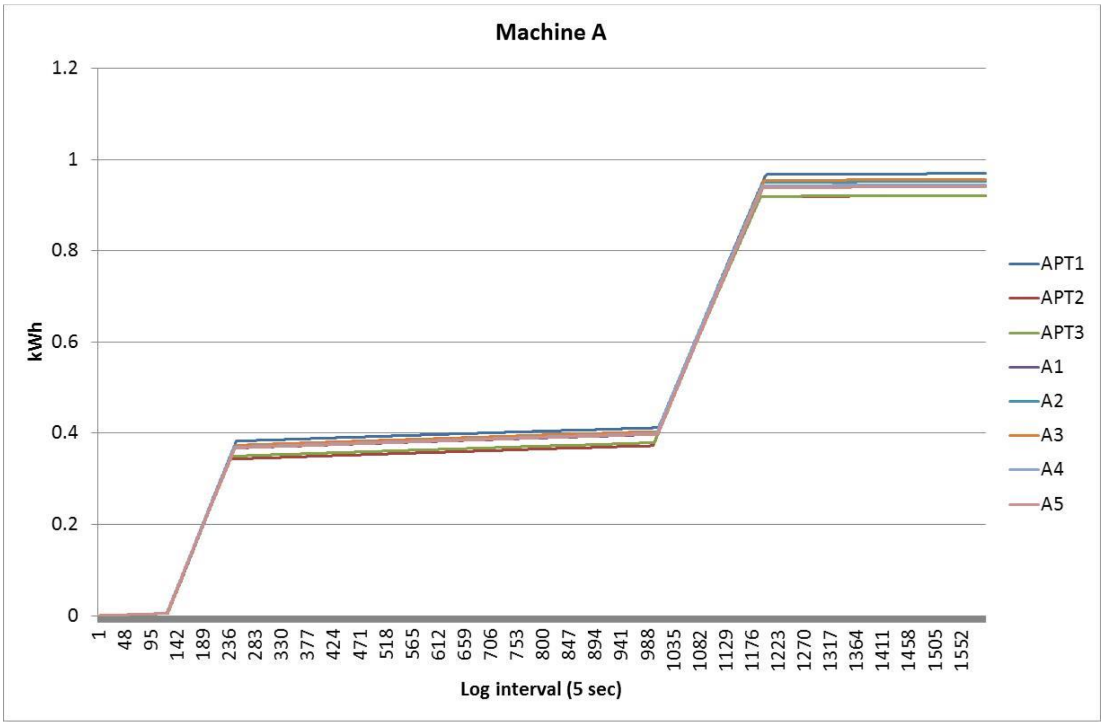


Figure 32: Energy profiles for all runs in Laboratory C for Machine A

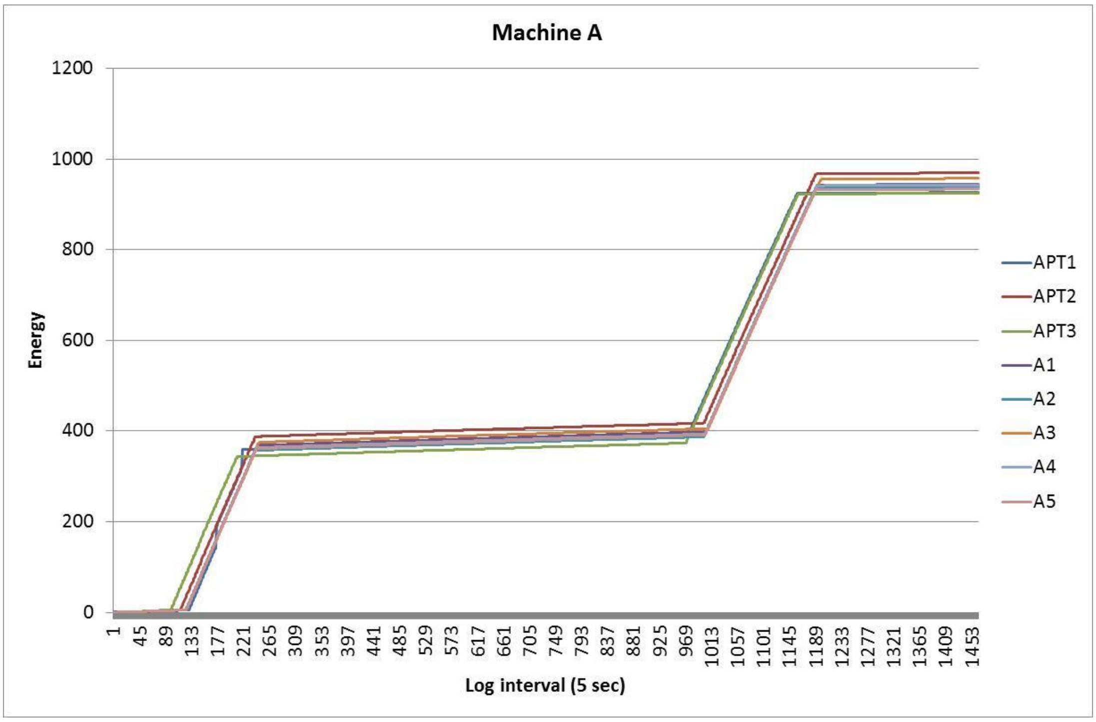
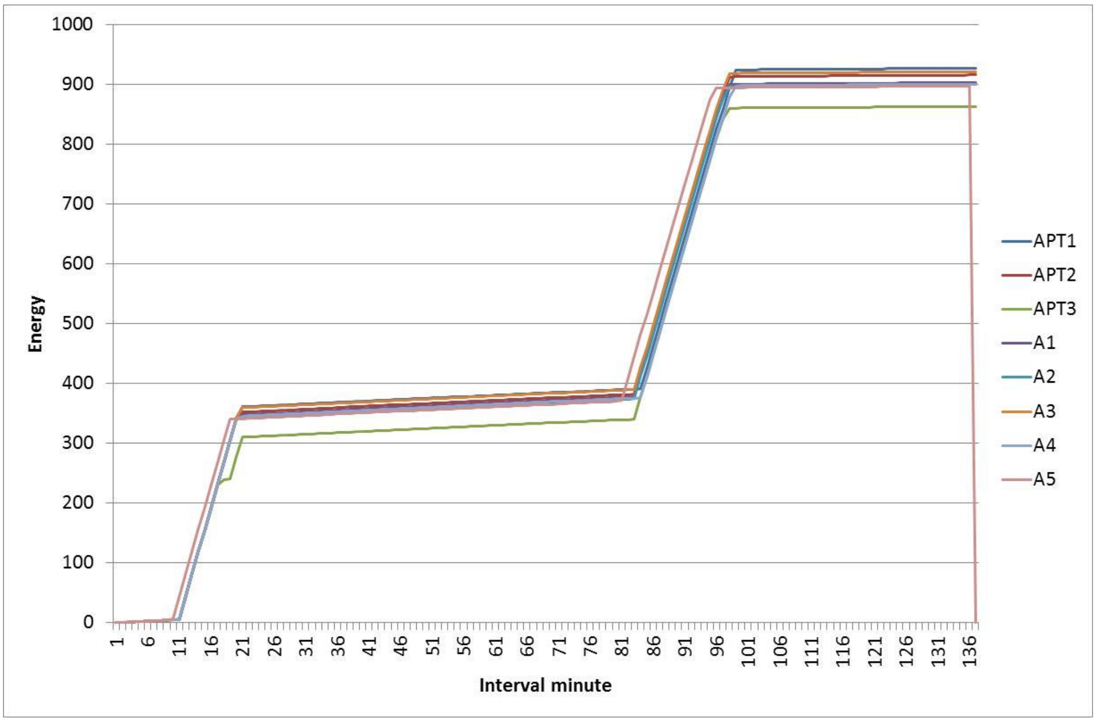


Figure 33: Energy profiles for all runs in Laboratory D for Machine A



Note: Pre-test APT3 may have started warm.

Figure 34: Energy profiles for all runs in Laboratory A for Machine C

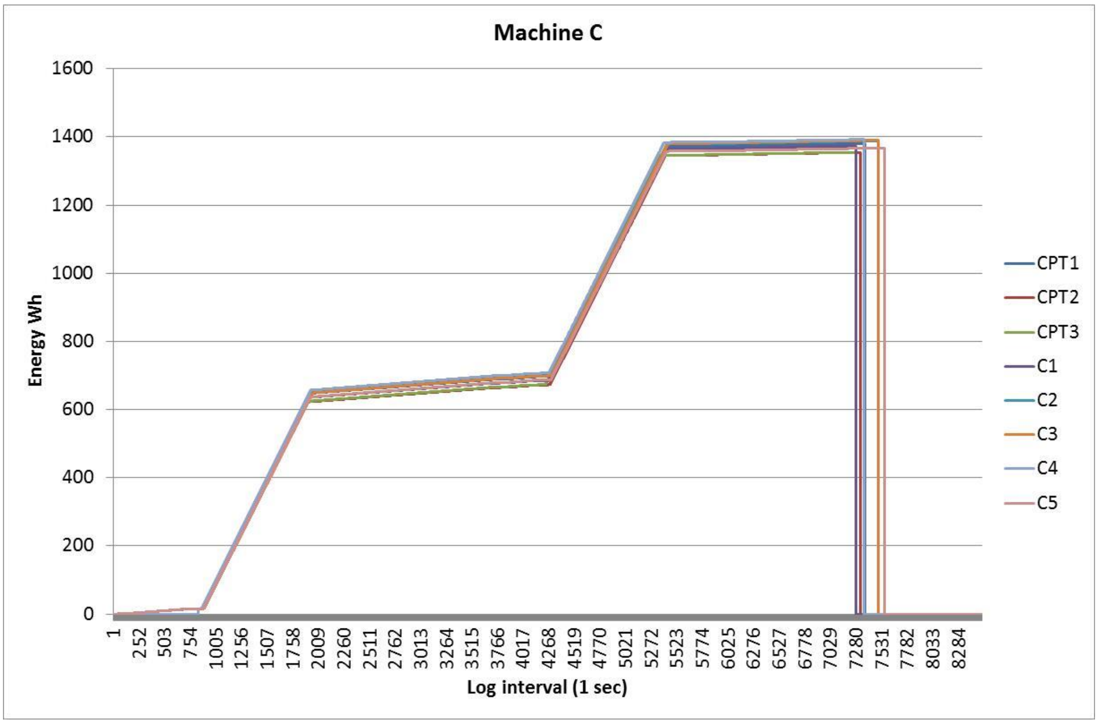


Figure 35: Energy profiles for all runs in Laboratory B for Machine C

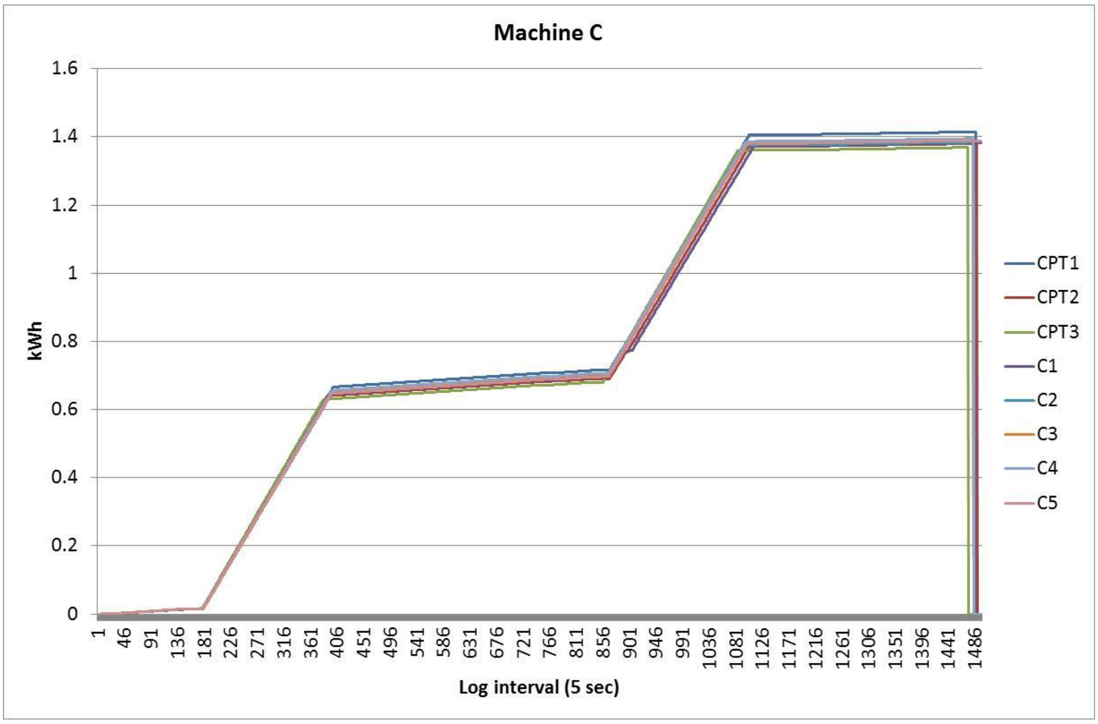


Figure 36: Energy profiles for all runs in Laboratory C for Machine C

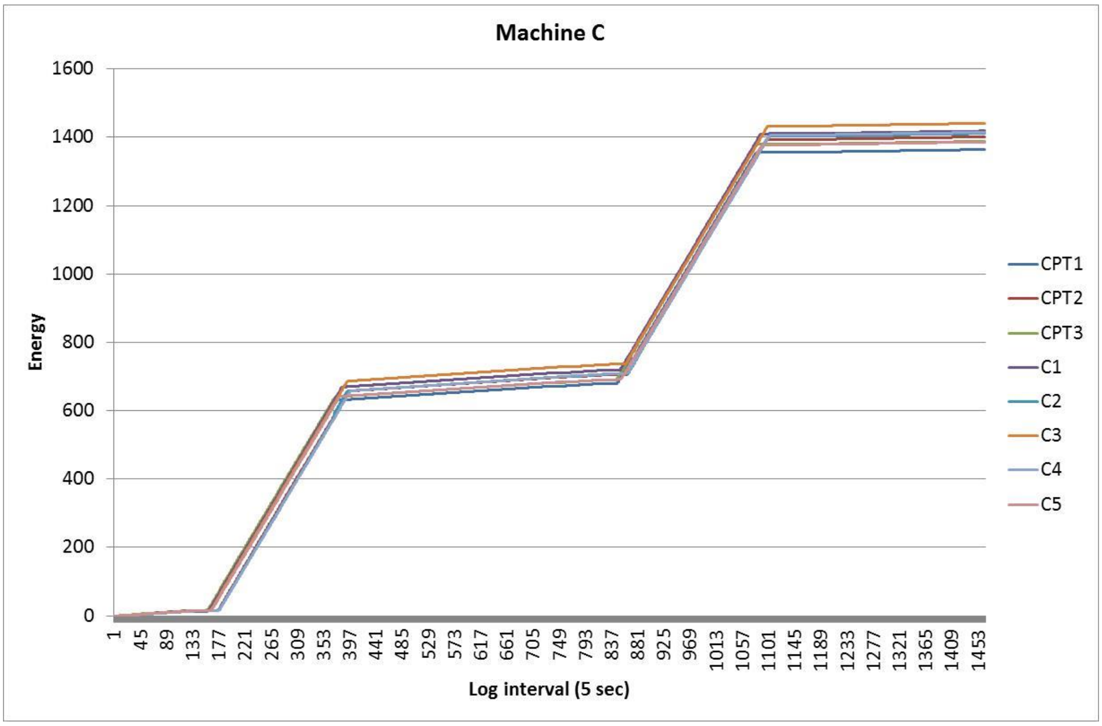
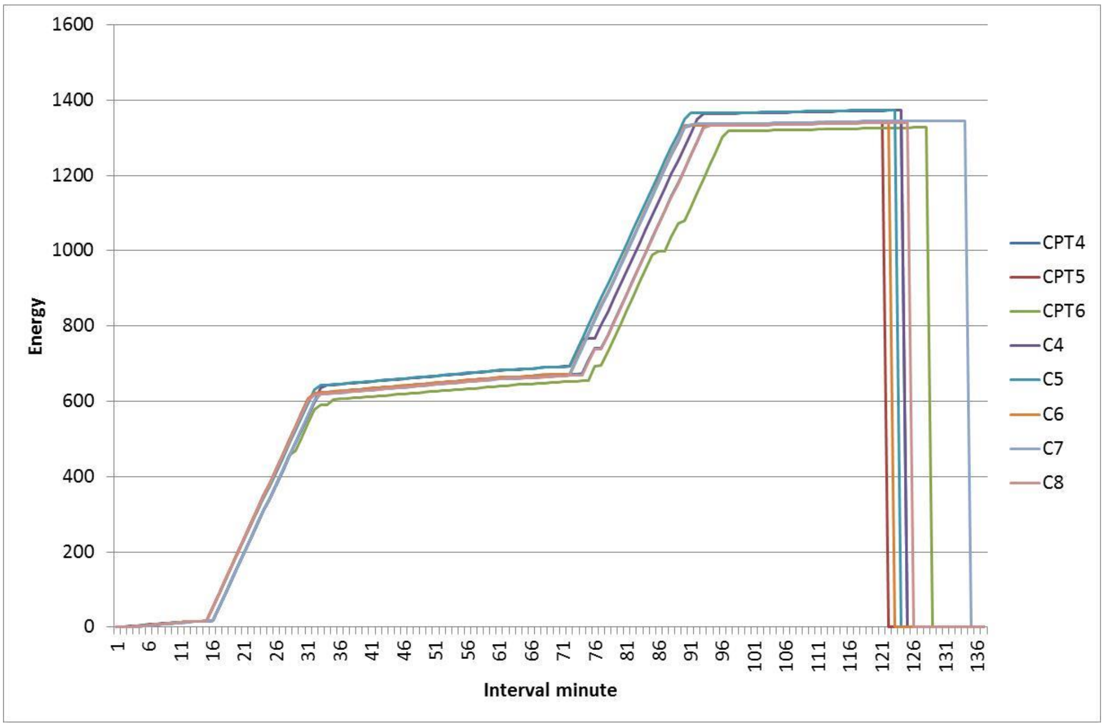
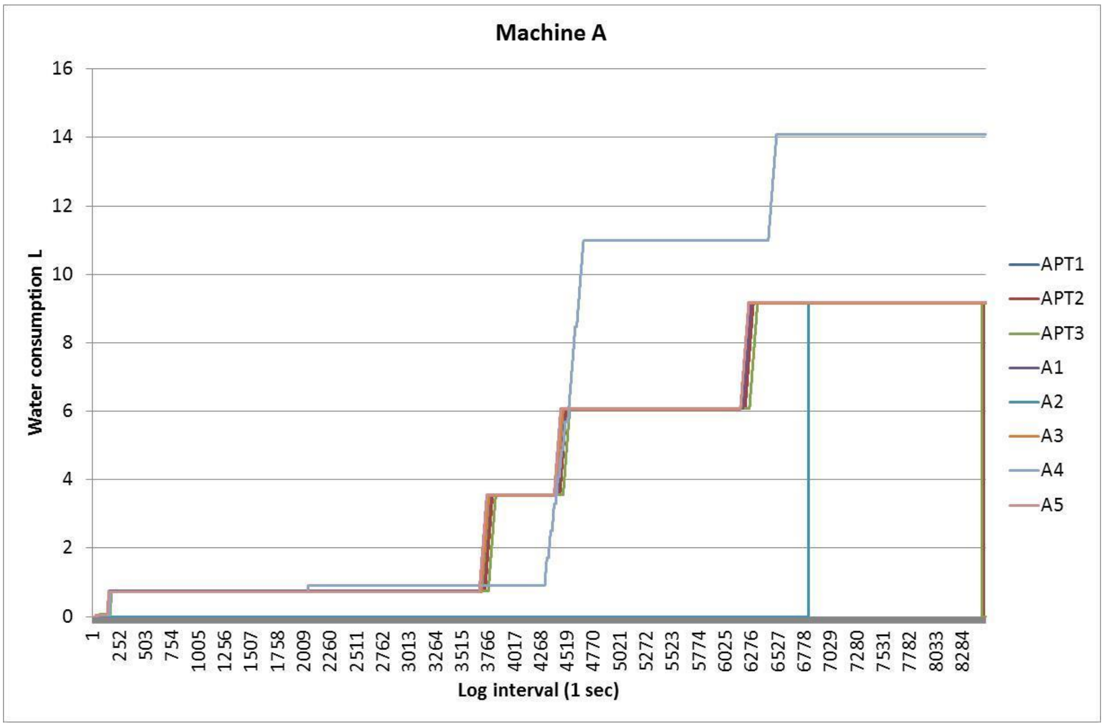


Figure 37: Energy profiles for all runs in Laboratory D for Machine C



Water discussion: Data on water consumed across all runs in each lab could be compared for consistency. Test machines appear to be operating in a very consistent manner in each lab. Run 4 on Machine A used additional water and hence more energy.

Figure 38: Water profiles for all runs in Laboratory A for Machine A



Note: Run A4 had additional water intake.

Figure 39: Water profiles for all runs in Laboratory B for Machine A

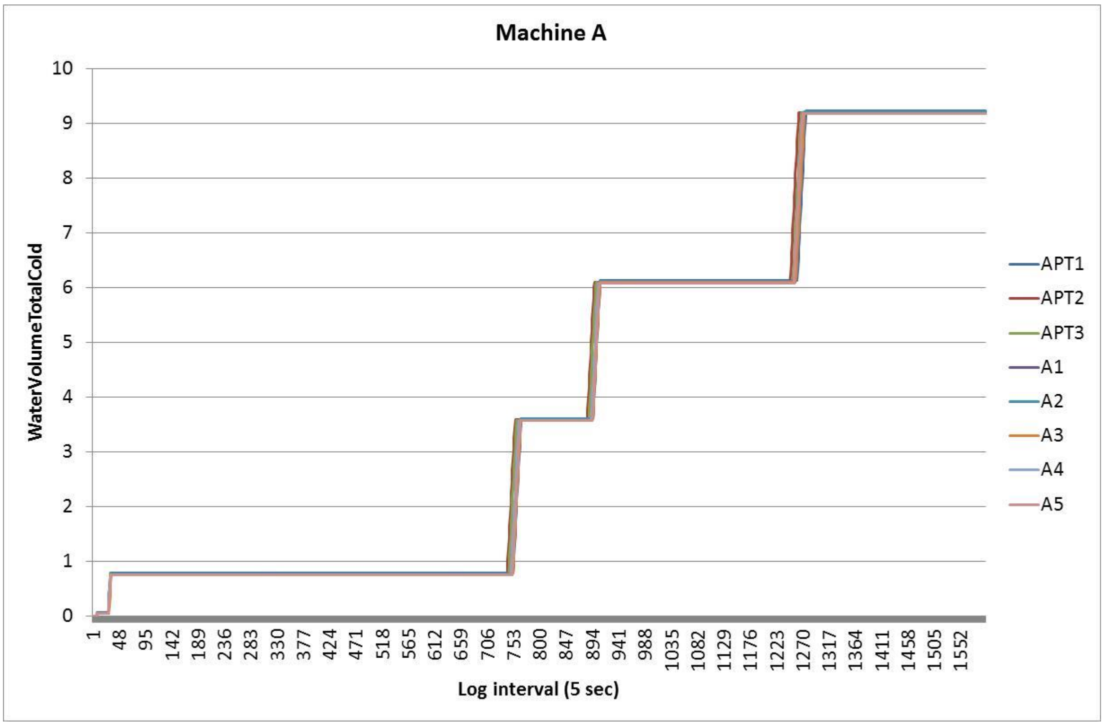


Figure 40: Water profiles for all runs in Laboratory C for Machine A

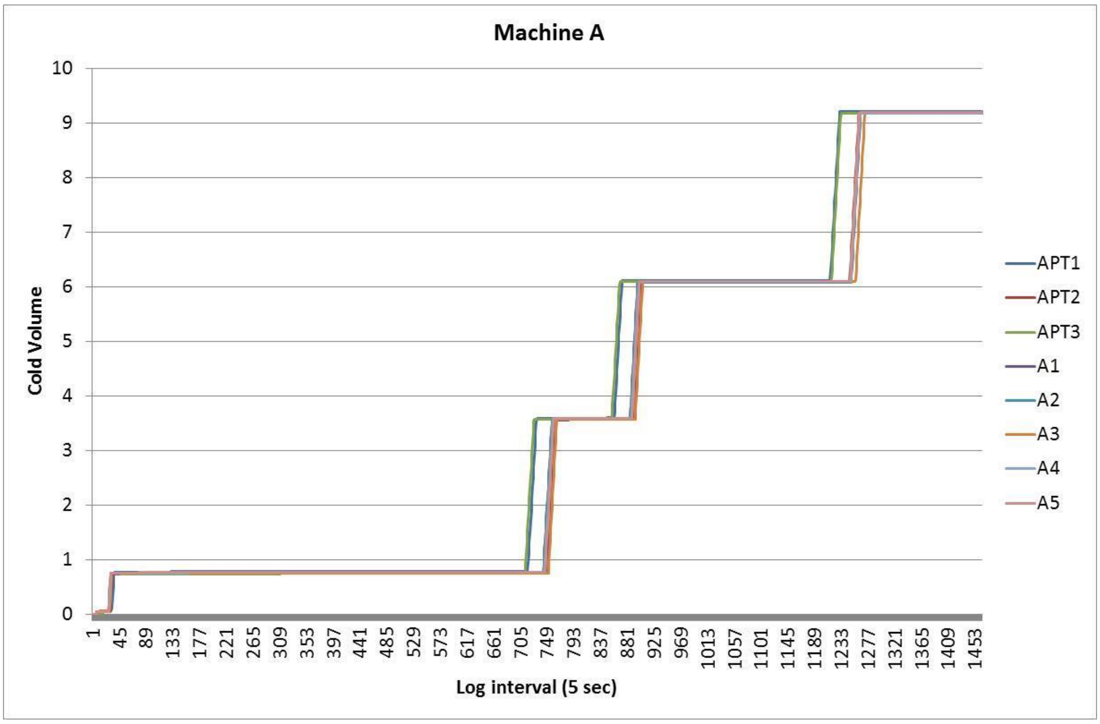


Figure 41: Water profiles for all runs in Laboratory D for Machine A

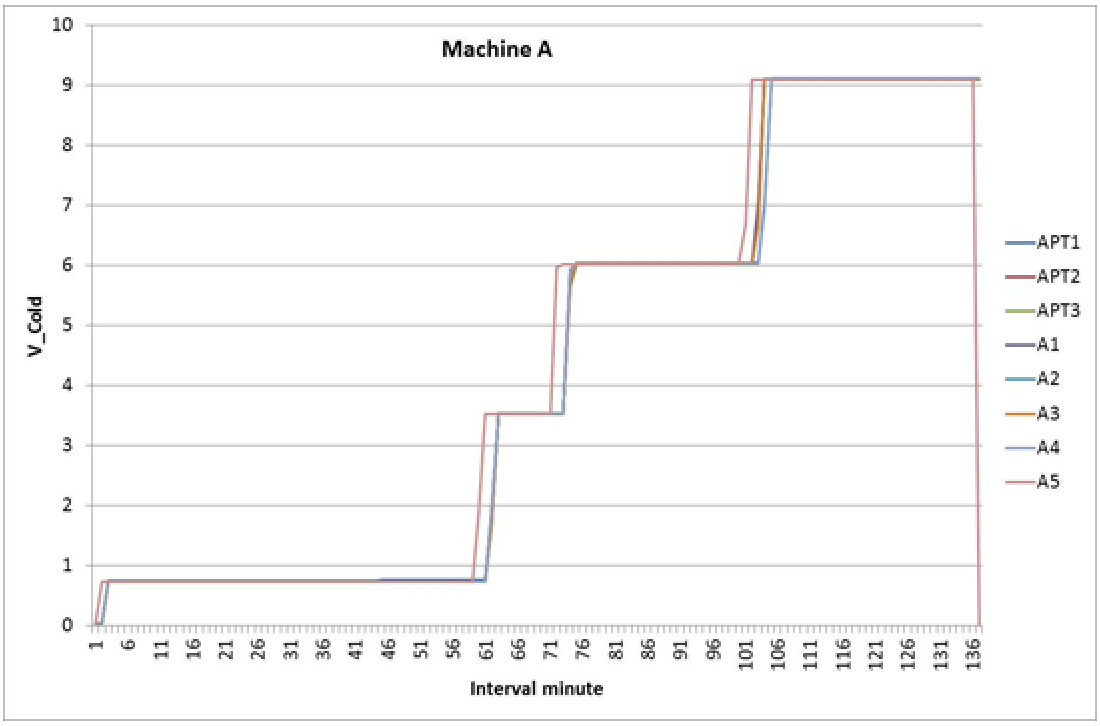


Figure 42: Water profiles for all runs in Laboratory A for Machine C

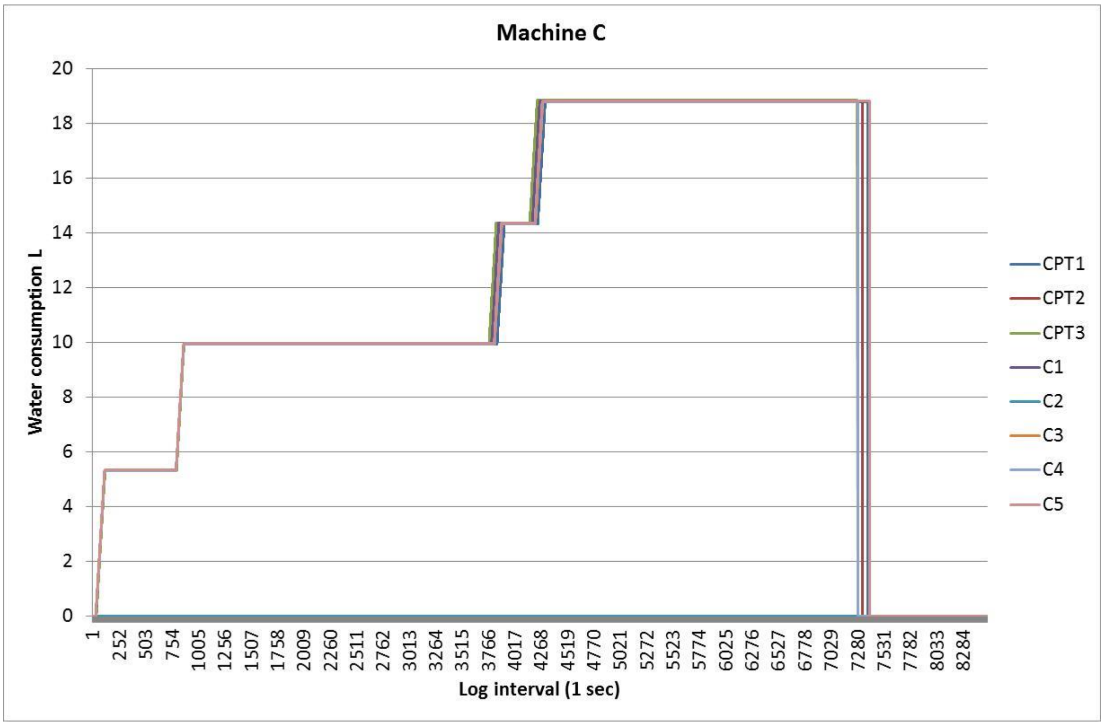


Figure 43: Water profiles for all runs in Laboratory B for Machine C

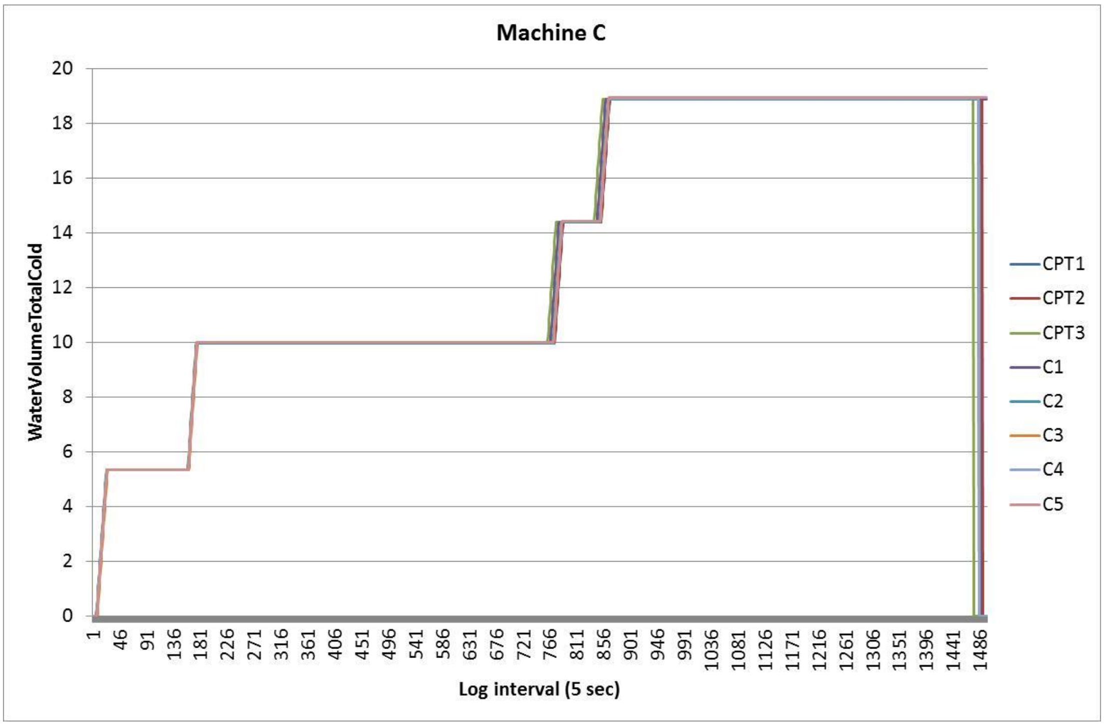


Figure 44: Water profiles for all runs in Laboratory C for Machine C

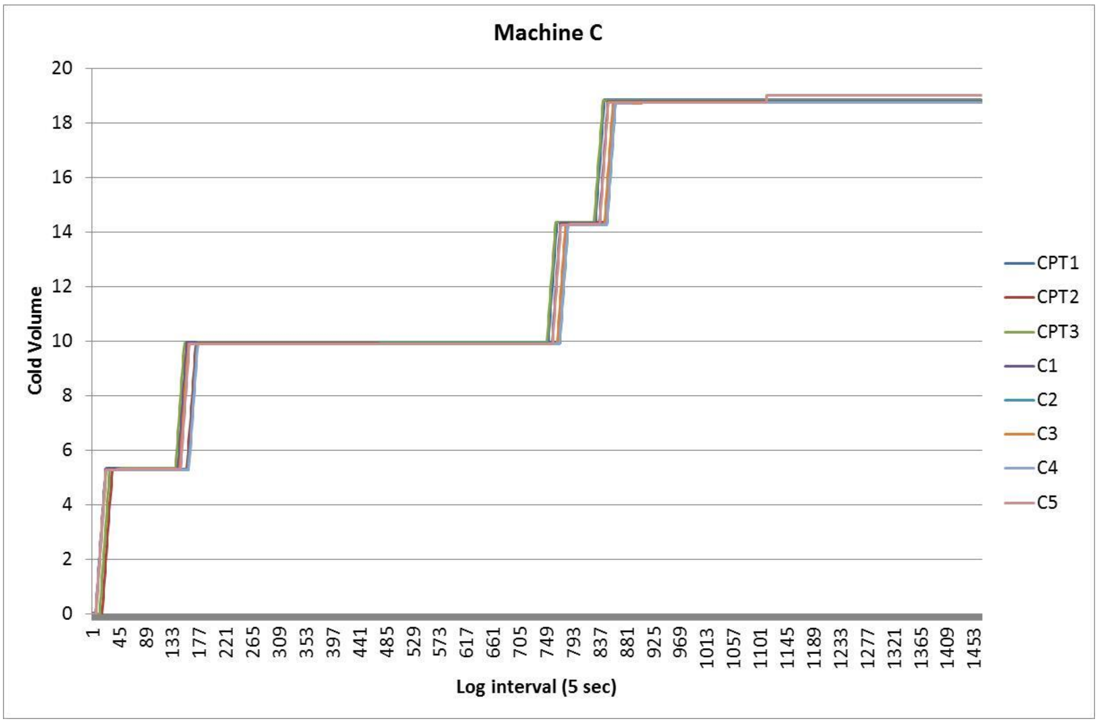
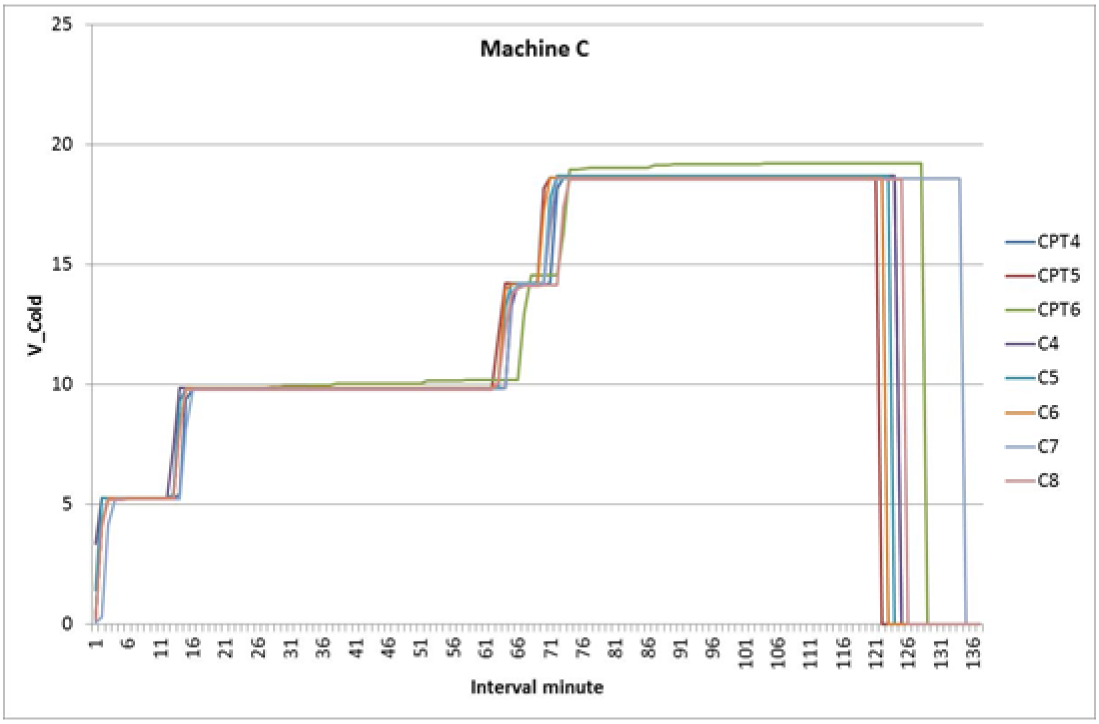


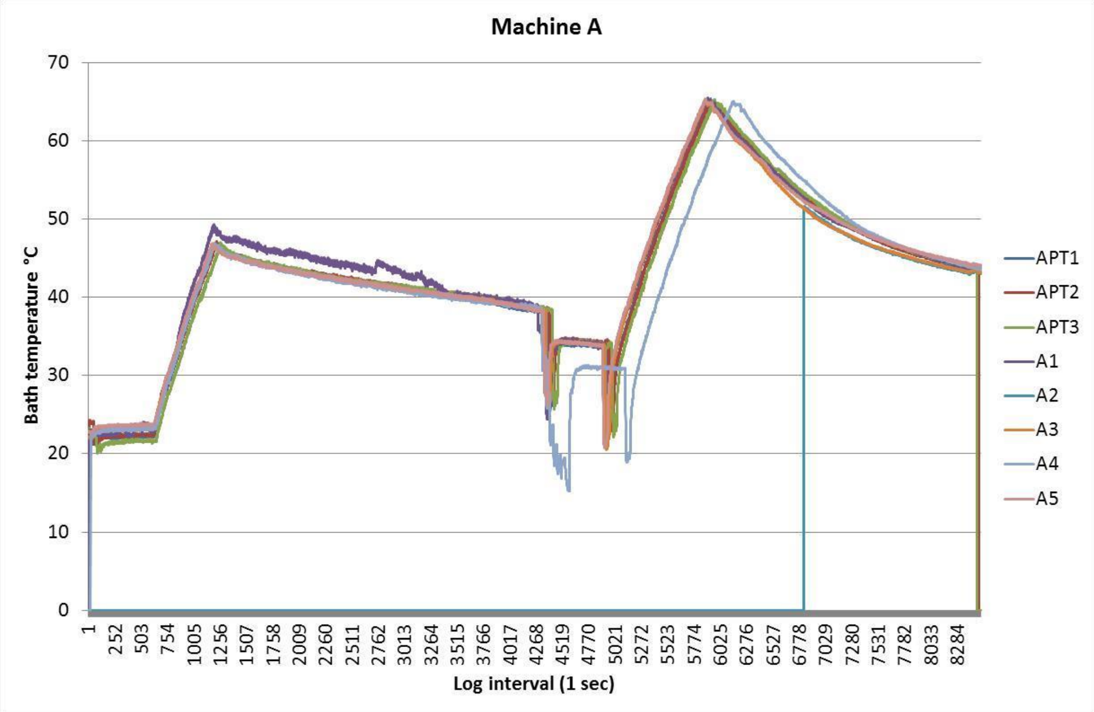
Figure 45: Water profiles for all runs in Laboratory D for Machine C



Note: Unclear why pre-trial run CPT6 used more water – could be regeneration of softener?

Sump temperature discussion: All labs showed very consistent data regarding internal temperatures measured in the sump of each dishwasher, indicating that they have accurate thermostats. Test machines appear to be operating in a very consistent manner in each lab. Only temperature profiles for Laboratory A have been shown. Run 4 on Machine A used additional water.

Figure 46: Sump bath temperature profiles for all runs in Laboratory A for Machine A



Note: Run A4 had additional water intake. Data recording issue on run A2. Some interference on run A1.

Figure 47: Sump bath temperature profiles for all runs in Laboratory A for Machine C