SUMMARY REPORT OF THE EGOLF ROUND ROBIN NO. TC2 19-1 IN FIRE RESISTANCE TESTING ON A DOORSET ACC. TO EN 1634-1

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1. INTRODUCTION

In 2019, EGOLF organised a round robin on fire resistance tests according to EN 1634-1 with 44 participating labs. This round robin enabled the participating laboratories to demonstrate their ability to perform this test method, to obtain regular results, and to express their trueness, precision and uncertainty of measurement.
This public report presents a summary of the results from the round robin. All participants are anonymous in this report.

1.1 SCOPE

1.1.1 Test construction

The test specimen is a doorset made of a steel insulated hinged door leaf (containing no discrete areas) and a steel door frame (four-sided one-piece frame, fully closed on the perimeter of the door, including a steel sill). The clear opening is 700 x 2000 mm.
The supporting construction is a low density rigid construction with a thickness of 150 mm.

As a part of the test construction, the mounting is a parameter that could contribute to the variability of the test results. The erection of the supporting construction has been managed by each participating lab as it is done for any ordinary test with any ordinary client. The labs have also been asked to carry out the mounting of the test specimen in the supporting construction with the greatest care possible following the given instructions.

1.1.2 Test method

The fire tests shall be performed in accordance with the requirements of the standards EN 1363-1 and EN 1634-1. EGOLF technical resolutions and recommendations shall be applied.
The performances to measure are:

- the integrity, through the following criteria:
  - the ignition of a cotton pad,
  - the penetration of gap gauges,
  - a sustained flaming,
- the insulation, through the following criteria:
  - the average temperature rise,
  - the maximum temperature rise - normal procedure,
  - the maximum temperature rise - supplementary procedure.

The test configuration is as follows:

- fire exposition: the fire exposure is "opening into the furnace", i.e. hinges exposed to the fire
- fire scenario: the fire scenario is the EN 1363-1 standard temperature/time curve (ISO 834)

1.1.3 Scheme of the experiment

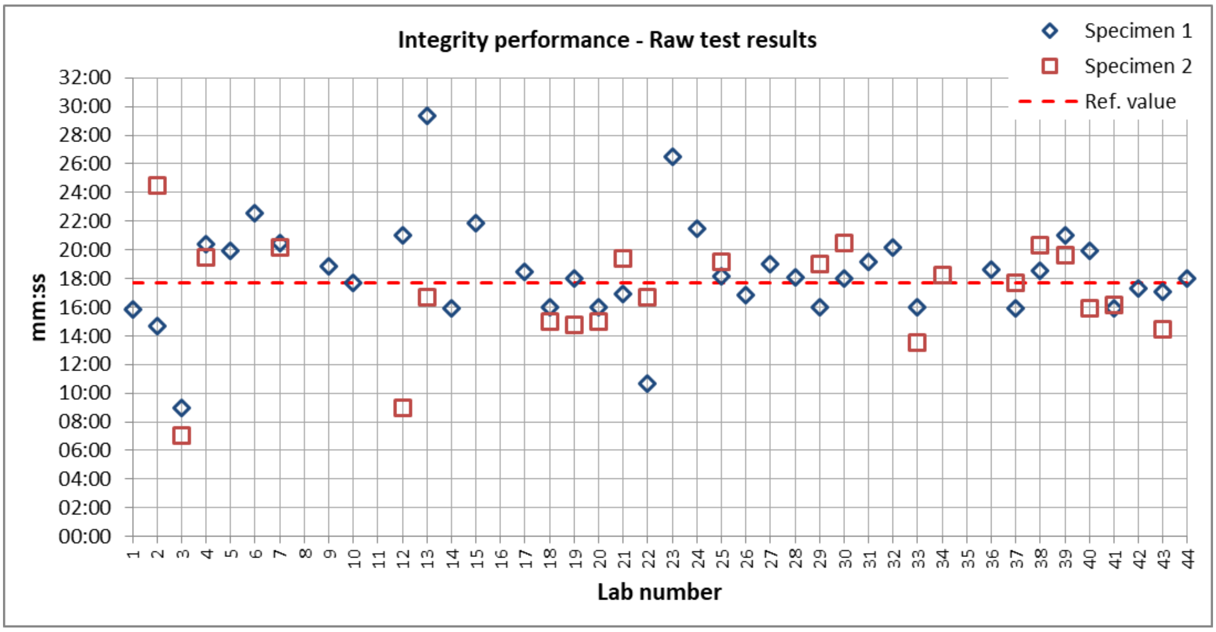
44 laboratories registered to this RR (*p=44*). It can be assumed that the number of laboratories participating to this RR is large enough to be a reasonable cross-section of the population of qualified laboratories using this test method. 18 labs registered to test 1 replicate of the test specimen, while 26

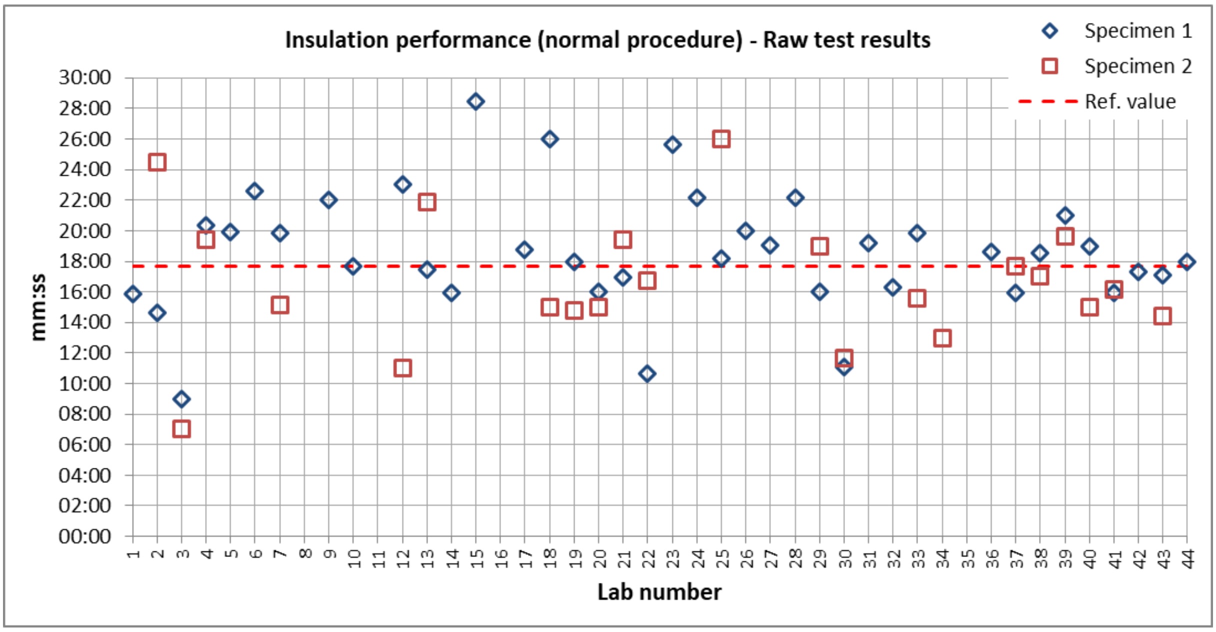
labs registered to test 2 replicates of the test specimen under repeatability conditions. All participating laboratories are EGOLF members and are accredited according to ISO 17025.

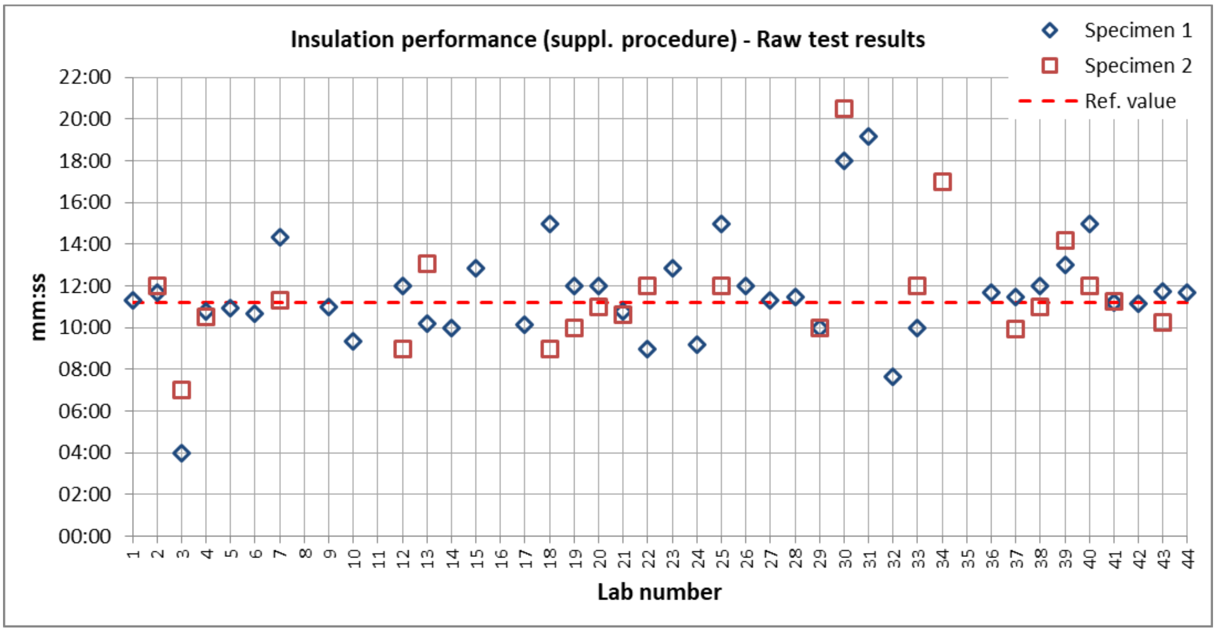
A total of 70 identical test specimens have thus been tested by the participating laboratories.

1.2 Original data

The raw data for the integrity and the insulation (normal and supplementary procedures) performances are presented in charts below. Raw data for each individual failure criterion have also been supplied by the participants and processed in the analyses but are not shown here. The wording "raw data" refers to "the data as they've been submitted by the participants", meaning that those data may possibly contain errors.
Missing data are due either to tests stopped before the occurrence of the corresponding mode of failure, or to tests performed outside the scope of this round robin so that their results cannot be recovered.







2. GENERAL ACCURACY EVALUATION

2.1 PURPOSE

The test specimen, the laboratories, the number of replicates, the instructions and the protocol of this experiment have been chosen to fully comply with the ISO 5725 prescriptions. As a result, the data processing tools presented in the ISO 5725 could also be implemented.

The first aim of the analyses is to work out as accurate as possible the best estimates of the fire resistance results of the specimen (reference values *m*) and quantitative measurements of the spread of the labs' results (repeatability standard deviations s_r and reproducibility standard deviations s_R).
Since it is useful to include as many correct results as possible in the estimations, all the necessary and possible corrections of the data are allowed for this purpose.

2.2 SELECTION OF REGULAR DATA

Since the accepted reference values are produced from the raw data submitted by the participating laboratories, the presence of irregular data could distort the estimates. Irregular data refers to:

- results incorrectly reported (results badly retrieved from the spreadsheets),
- results arising from tests not carried out under repeatability conditions,
- results arising from tests not complying with standards requirements and instructions,
- results identified as outliers (as detected by specific statistical tests).

A deep inspection of the data has been carried out, lab by lab and test by test, to detect such deviations. The results badly retrieved have been corrected. The whole tests not complying with testing standards and that could not be recovered, as well as the single test results detected as outliers, have been discarded. No test has been identified out of the repeatability conditions.

2.3 EXPRESSION OF GENERAL ACCURACY RESULTS

The regular data have finally been used to compute the general accuracy results that are presented in the tables below, in the format mm:ss (uncertainties are expressed relative to the reference value *m*).

	INTEGRITY			
	Criteria			Performance
	Cotton pad	Gap gauges	Sustained flaming	Integrity
General mean = Reference value = m	17:53	22:48	18:09	17:44
Repeatability standard deviation = s_r	02:08	02:30	01:22	02:03
Within-lab average expanded uncertainty = U_r	23%	21%	15%	23%
Repeatability limit = r	05:57	06:59	03:49	05:44
Reproducibility standard deviation = s_R	02:08	08:20	02:04	02:16
Between-lab expanded uncertainty = U_R	23%	72%	22%	25%
Reproducibility limit = R	05:57	23:20	05:47	06:22

	INSULATION				
	Criteria			Performance	
	Average temp. rise	Max. temp. rise - Normal	Max. temp. rise - Suppl.	Insulation - Normal (I_2)	Insulation - Suppl. (I_1)
General mean = Reference value = m	28:10	21:50	11:12	17:40	11:12
Repeatability standard deviation = s_r	00:55	02:14	01:08	01:36	01:08
Within-lab average expanded uncertainty = U_r	6%	20%	20%	18%	20%
Repeatability limit = r	02:33	06:14	03:09	04:29	03:09
Reproducibility standard deviation = s_R	07:03	05:50	01:20	01:58	01:20
Between-lab expanded uncertainty = U_R	49%	52%	23%	22%	23%
Reproducibility limit = R	19:45	16:20	03:45	05:31	03:45

2.4 INTERPRETATION

The **general mean** *m* is the best estimate of the test result. This is the result that would be produced by a "perfect lab" performing a "perfect test".

The **repeatability** (resp. **reproducibility**) **standard deviation** s_r (s_R) is the standard deviation of test results – obtained under repeatability (reproducibility) conditions – that may be expected on average within (between) labs.

The **within-lab average** (resp. **between-lab**) **expanded uncertainty** U_r $(= 1{,}96\ s_r)$ (U_R $(= 1{,}96\ s_R)$) provides the relative uncertainty (expanded at a confidence level of 95%) on test results – obtained under repeatability (reproducibility) conditions – that may be expected on average within (between) laboratories.

The **repeatability** (resp. **reproducibility**) **limit** *r* (*R*) is the value below which the absolute difference between two test results obtained under repeatability (reproducibility) conditions may be expected to lie with a probability of 95%.

These limits depict in what proportions the test results are spread because of all the factors encountered when testing a door according to the standards EN 1363-1 and EN 1634-1 (differences in handling and positioning the test specimen, differences in instrumentations and calibrations, differences in furnaces and other equipment, differences in operators, differences in procedures and calculations…).

In other words, when testing a steel doorset with a fire resistance of approximately 15~20 minutes, one could expect to reach a relative expanded uncertainty on the test result of 25% for the integrity performance, 22% for the insulation performance (normal procedure), and 23% for the insulation performance (supplementary procedure) (at a confidence level of 95%).

3. INDIVIDUAL PERFORMANCE EVALUATION

3.1 PURPOSE

The second aim of the analyses is to produce individual accuracy results from the raw data submitted by the laboratories. These individual accuracy results consist of the bias (trueness) and the standard deviation (precision) for each lab. The performance of each lab can then be deduced by comparison of these values with the general accuracy results produced above.

This section implements some simple graphical and numerical criteria to these labs' individual accuracy results. Those methods, presented in the ISO 13528, allow deducing a clear picture of the performances of the laboratories.

3.2 STARTING DATA

For each laboratory, the within-lab mean ($\bar{y_i}$), the bias ($\Delta_i = \bar{y_i} - m$) and the within-lab standard deviation (s_i) are calculated from the raw results submitted by the labs. The bias and the standard deviation express the trueness and the precision of the labs respectively.

The closer the within-laboratory mean ($\bar{y_i}$) is to the reference value (*m*), the smaller the lab's bias (Δ_i), the better the lab's trueness. Such a comparison is quantified by the z-scores below.

The smaller the within-laboratory standard deviation (s_i) is, the smaller the lab's variability, the better the lab's precision. Such a comparison is quantified by the k-scores below.
The global accuracy of a laboratory results from these two components.

3.3 SCORES

- The z-score is a performance statistic that depicts the bias and thus the trueness of a laboratory (how close the within-laboratory mean $\overline{y_i}$ is to the reference value m). It is defined by
$$z_i = \frac{\overline{y_i} - m}{s^*}$$
where s* is the robust standard deviations for proficiency testing s*
- The k-score is a performance statistic that depicts the variability and thus the precision of a laboratory (how small the within-laboratory standard deviation s_i is). It is defined by
$$k_i = \frac{s_i}{s_r}$$

The interpretation of these scores is simple:

- $|score_i| \leq 2$: the trueness/precision performance of the lab is satisfactory (the lab's mean/standard deviation is found to fall approximately within the 95% range of values with the more probability occurrence),
- $2 < |score_i| \leq 3$: warning signal, the trueness/precision performance of the lab is questionable (the lab's mean/standard deviation is found to fall approximately within the 5% range of values with the less probability of occurrence),
- $3 < |score_i|$: action signal, the trueness/precision performance of the lab is unsatisfactory (the lab's mean/standard deviation is found to fall approximately within the 0,3% range of values with the less probability of occurrence).

The table below presents the number of labs affected by warning and action signals for each failure criteria and performance.

Score	Signal	**INTEGRITY**				**INSULATION**				
		Criteria			Performance	Criteria			Performance	
		Cotton pad	Gap gauges	Sustained flaming	Integrity	Average temp. rise	Max. temp. rise - Normal	Max. temp. rise - Suppl.	Insulation - Normal (I_2)	Insulation - Suppl. (I_1)
z	Warning	0	0	1	4	0	0	2	7	2
	Action	4	0	2	2	0	0	1	4	4
k	Warning	0	0	1	1	0	1	0	2	0
	Action	4	2	1	3	3	2	1	4	1

4. FURTHER EXPLORATION

The third aim of the analyses is to explore the masses of data submitted by the participants to draw up advanced investigation about several parameters of the standard methods.

Among others, these analyses highlight that most of the laboratories still meet difficulties to comply with all the most fundamental requirements of the test standards EN 1363-1 and EN 1634-1. A deep inspection has been carried out to detect the deviations from the standard requirements, resulting in a detailed overview of the frequency of occurrence of each non-compliance. In particular, the abilities of the labs to retrieve the correct test results from the recorded raw values, to meet each tolerance related to the furnace temperature and the furnace pressure, and to position the mandatory unexposed face thermocouples correctly on the test specimen have been quantified.

The above in-depth processing applied to the data clearly identifies the technical fields that requires close attention. EGOLF will cover and follow up these areas of improvement by means of action plans. One of the challenges will be to identify the root causes of the problems, whatever they may be (e.g. unsuitability of some testing facilities, lack of training and awareness of the personnel, complexity of the testing methods, ineffective skill transfer within the labs etc.). Inter alia, it is already clear that the test standards contain some unclear or conflicting requirements. This information will be forwarded to CEN/TC 127.