Bauforschung

Entwicklung eines Prüfverfahrens zur Beurteilung des Brandverhaltens von Baustoffen

Abschlußbericht Tl. 1
Auswertung

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Abschlußbericht Teil 1

Auswertung

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Materialprüfungsamt NRW

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Versuchsergebnisse des MPA NRW im Zuge der Rundversuche

1. Aufgabenstellung

Im Zuge der europäischen Harmonisierung der Prüfverfahren zum Brandverhalten von Baustoffen wurde von der EU-Kommission ein Beurteilungskonzept veröffentlicht, das von 6 Euro-Klassen (A - F) zur Kennzeichnung des Brandverhaltens ausgeht. Für die Euro-Klassen B, C und D sieht die Klassisifzierungstabelle vor, daß die Beurteilung auf den Ergebnissen des SBI-Tests basiert. Für alle übrigen Klassen werden bereits existierende Prüfverfahren, die entweder national oder im Rahmen der internationalen Normung entwickelt worden sind,eingesetzt. Für den SBI-Test war dies nicht möglich, da für die in Frage stehenden Brandeigenschaften kein Prüfverfahren vorhanden war, das einerseits die verschiedenen derzeit in den Mitgliedsländern vorhandenen Sicherheitsniveaus berücksichtigt, andererseits dem Anspruch an ein wissenschaftliches Auswerteverfahren genügt und die Möglichkeit bietet, die Meßdaten zur rechnerischen Erfassung von Brandabläufen einzusetzen. Die derzeit in den Mitgliedsländern für diesen Bereich angewandten Prüfverfahren unterscheiden sich voneinander grundlegend und in einer Vielzahl von Ausführungs- und Prüfdetails, so daß eine Übertragbarkeit der Versuchsergebnisse nach einem nationalen Prüfverfahren auf die übrigen nationalen Prüfverfahren nicht möglich ist.

Um zu einem harmonisierten Prüfverfahren zu gelangen, beauftragte die EU-Kommission eine Gruppe von 7 Laboratorien mit der Entwicklung eines Prüfverfahrens. Die Zahl der Laboratorien wurde in der Zeit nach der Auftragserteilung aufgrund des Beitritts weiterer Länder zur EU um 2 Laboratorien erweitert. Die Vorgaben für die Entwicklung des Prüfverfahrens wurden von der EU-Kommission auf der Basis von Beratungsergebnissen der Gruppe der Regulators gemacht.

Sie sahen folgende Versuchsrandbedingungen vor:

- Anordnung der Proben zu einer Raumecke
- Probenhöhe 1,5 m
- Probenbreite an einer Probenseite 1 m, an der anderen Seite 0,5 m
- Beaufschlagung der Proben mit einer Zündquelle, die im unmittelbaren Beanspruchungsbereich eine Wärmebeaufschlagung von ca. 40 kW/m^2 erzeugt. Die Wärmebeaufschlagung sollte nach oben zu langsam abnehmen, so daß in halber Probenhöhe (0,75 cm) ein Niveau von ca. 10 kW/m^2 erreicht wird. Zu den Seiten zu sollte die Beanspruchung abrupt abnehmen.
- Absaugung der Rauchgase über eine Rauchabzugsvorrichtung, in der die notwendige Meßtechnik installiert wird.
- Zuluft durch natürlichen Auftrieb geregelt.

Der zu entwickelnde Brandversuch sollte die Durchführung von Messungen erlauben, deren Ergebnisse unmittelbar in eine rechnerische Beschreibung des Brandes eingehen können. Im Einzelnen sollten folgende Parameter bestimmt werden

- Zeitpunkt bis zur Entzündung
- Flammenausbreitung (vertikal, horizontal)
- Temperaturverlauf im Abgasstrom
- Energiefreisetzung in Abhängigkeit von der Zeit (Sauerstoffverbrauchsmethode)
- Rauchdichteverlauf im Abgas als Maß für die Rauchentwicklung
- Registriermöglichkeit für das brennende Abtropfen/Abfallen brennender Teile

Die Entwicklung des Prüfverfahrens und die Konstruktion der erforderlichen Prüfapparatur sollten nach ingenieurmäßigen Verfahren und Maßstäben erfolgen, die den Einsatz des Prüfverfahrens bei routinemäßig ablaufenden Prüfungen im Zuge der standardmäßigen Beurteilung der Produkte erlauben. Dabei war von einer großen Zahl von Prüfungen auszugehen. Selbstverständlich waren bei der Entwicklung des Prüfverfahrens arbeitsschutztechnische Gesichtspunkte zu berücksichtigen.

2. Ablauf der Arbeiten

Die Arbeit wurde als Gemeinschaftsentwicklung durchgeführt, an der alle beauftragten Laboratorien beteiligt waren. Die Laboratorien waren so ausgewählt, daß jeweils 1 Laboratorium pro Mitgliedsland (soweit an der Beteiligung interessiert) einbezogen wurde. Die Liste der beteiligten Laboratorien ist nachstehend aufgeführt.

CSTB	Centre Scientifique et Technique du Batiment	F
DIFT	Danish Institute for Fire Technique	DK
FRS	Fire Research Station	UK
LSF	Laboratorio di Studi e Ricerche sul fuoco	I
MPA	Materialprüfungsamt NRW	D
RUG	Rijksuniversiteit Gent	B
SP	Statens Provningsanstalt	S
TNO	TNO Building and Construction Research	NL
VTT	Technical Research Centre of Finland	FI

Die Arbeit wurde in folgenden Detailschritten durchgeführt:

- Entwurf des Versuchskonzepts und der dafür erforderlichen Apparatur (einschl. Werkstattzeichnungen)
- Bau von 1 bzw. 2 Prototypen der Versuchsapparatur, Inbetriebnahme und Erprobung der Prototypen
- Entwicklung der Software zur Meßwerterfassung und -verarbeitung
- Festlegung der endgültigen Konfiguration der Versuchsbedingungen, der Meßtechnik und der Betriebsweise des Versuchs
- Bau, Inbetriebnahme und Kalibrierung weiterer Versuchseinrichtungen
- Durchführung von Rundversuchen
- Versuche an einer großen Zahl von Materialien zur Schaffung einer Datenbank über das Verhalten der Produkte in diesem Test
- Versuche im Maßstab 1:1 in der Versuchseinrichtung nach ISO 9705 zur Feststellung der Korrelation zwischen dem Laborprüfverfahren und dem Verhalten der Produkte in größerem Maßstab.

Umfang und Reihenfolge der o.a. Arbeitsschritte wurden im Laufe der Arbeit mehrfach den sich aus den Versuchsergebnissen resultierenden Bedürfnissen angepaßt. Gleiches gilt für die Aufteilung der Arbeiten auf die beteiligten Laboratorien. Insbesondere im Hinblick auf die geplanten Rundversuche und die Versuche an einer großen Zahl von Materialien zur Schaffung einer Datenbank ergaben sich im Laufe der Bearbeitung des Vorhabens Änderungen. Anstelle der ursprünglich für die Durchführung der Rundversuche vorgesehenen 10 Materialien wurden diese auf 30 Materialien ausgedehnt. Die Zahl der Materialien für die Schaffung einer Datenbank wurde auf insgesamt 100 gekürzt - einschl. der 30 Materialien, die bereits bei den Rundversuchen eingesetzt wurden. Die Durchführung der Untersuchungen an den übrigen 70 Materialien soll nachträglich erfolgen.

Die Entwicklung des Prüfverfahrens erfolgte in enger Abstimmung mit der von der EU-Kommission hiermit beauftragten Gruppe der Regulators. Dieser Gruppe wurde regelmäßig über Arbeitsfortschritte und Zwischenergebnisse berichtet. Entscheidungen über verschiedene Alternativlösungen, die sich im Zuge der Entwicklung ergaben, wurden in Abstimmung mit dieser Gruppe getroffen. In vielen Fällen war es notwendig, zusätzlich Erprobungsversuche durchzuführen, um den Einfluß der Variationsmöglichkeiten zu untersuchen. Der dadurch bedingte, gegenüber der ursprünglichen Arbeitskonzeption erheblich gesteigerte Aufwand hatte zur Folge, daß die Arbeiten nicht in der ursprünglich vorgesehenen Frist erledigt werden konnten. Außerdem wurden hierdurch deutlich erhöhte Kosten verursacht. Ein Antrag zur Bezuschussung dieser Arbeiten aufgrund des o.a. zusätzlichen Arbeitsaufwandes bei der EU-Kommission wurde gestellt.

3. Vorversuche

Um eine Grundlage für die später festzulegenden apparativen Ausstattungen der Versuchseinrichtung zu erhalten, war es zunächst erforderlich, Untersuchungen über eine zweckmäßige Beanspruchungsquelle anzustellen, mit der die o.a. Vorgaben der EU-Kommission im Hinblick auf die Brandbeanspruchung erfüllt wurden.

Hierzu wurden im MPA NRW Brandversuche in dem Brandschacht nach DIN 4102 Teil 1 - jedoch mit geänderten Brennerformen -durchgeführt. Zur Erprobung wurden auch ein nicht rechtwinkliger Reihenbrenner sowie ein rechtwinklig angeordneter Reihenbrenner mit unterschiedlichen Schenkellängen eingesetzt. Dabei wurde grundsätzlich von einer Beanspruchung mit einem Propanbrenner ausgegangen, bei dem das Gas und die notwendige Luft vor Austritt aus den Brennerdüsen vorgemischt waren. Durch diese Brenner ergab sich eine vergleichsweise stabile, gut definierte Flammenform. Die Versuche wurden bei unterschiedlichen Gas-Luft-Durchsätzen durchgeführt.

Bei diesen Versuchen wurde die Wärmeflußdichte im unmittelbar beflammten Bereich sowie die Temperaturverteilung über die Höhe gemessen. Die Ergebnisse dieser Untersuchungen sind im Abschlußbericht Teil 2 Abschnitt 1 zusammengestellt.

Parallel dazu wurden in der CSTB Versuche mit einem quaderförmigen Brenner durchgeführt. In der Universität Gent (RUG) wurden Versuche mit 2 verschiedenen Sandbettbrennern durchgeführt. Bei der Fire Research Station (FRS) wurden Versuche mit Holzkrippen durchgeführt.

Auf der Basis der o.a. Vorversuche wurde der Beschluß gefaßt, für die weiteren Arbeiten folgende vier Beanspruchungsquellen weiter zu verfolgen:

- gasbeheizter Strahler
- elektrobeheizter Strahler
- Sandbettbrenner mit Diffusionsflamme
- Düsenbrenner mit vorgemischtem Gas-Luft-Gemisch

Die entsprechenden Beanspruchungsquellen wurden gebaut und in verschiedenen Stellen erprobt. Bei einer ersten Versuchsserie zeigte sich folgendes:

- Der elektrobeheizte Strahler hatte den Nachteil, daß der Abstand zur Probe - um das gewünschte Wärmeflußprofil zu erreichen - sehr gering gewählt werden mußte (ca. 50 mm), so daß eine Beobachtung des Verhaltens der Probe sowie die ungestörte Brandausbreitung an der Probe nicht mehr gewährleistet waren.

- Der mit vorgemischtem Gas-Luft-Gemisch arbeitende Düsenbrenner wurde abgelehnt, da die Flammenform und -größe hierbei konstant und stabil waren, so daß bei schrumpfendem Material die Beanspruchung des Materials nicht mehr möglich war.

- Für den gasbeheizten Strahler wurden zwei unterschiedliche Konzeptionen eingesetzt:

  * Ebener gasbeheizter Strahler entsprechend der amerikanischen Norn ASTM E 648, bei dem das Gas durch die poröse Oberfläche austritt und an der Oberfläche verbrennt - dieser Strahler brachte nicht das geforderte Wärmeflußprofil.

  * Mit geschlossener Brennkammer arbeitender Strahler (in einem mit feuerfester Ausmauerung versehenem Brennergehäuse wird das Brenngas verbrannt; an den in der Probenecke liegenden Seiten ist eine eckförmige Strahlerfläche aus Silicium-Carbid angeordnet, die nach Vorheizung das entsprechende Strahlungsflußprofil erzeugt) - dieser Strahler brachte Probleme im Hinblick auf die Haltbarkeit der winkelförmigen Strahlerplatte mit sich.

Die Ergebnisse der Voruntersuchungen wurden der Arbeitsgruppe berichtet (siehe Abschlußbericht Teil 2). Im wesentlichen aus Gründen der praktischen Handhabbarkeit wurde die Entscheidung getroffen, die weitere Entwicklung mit dem Sandbettbrenner fortzuführen.

Im Hinblick auf die Meßungen konnte im wesentlichen auf bekannte Techniken aus anderen Prüfverfahren zurückgegriffen werden. Lediglich im Hinblick auf die vertikale Flammenausbreitung wurden Schwierigkeiten vorhergesehen, da eine visuelle Beobachtung, wie sie bisher ausgeführt wurde, als zu subjektiv angesehen wurde. Aus diesem Grunde wurde der Versuch unternommen, mit Hilfe von optischen Meßverfahren (Lichtstrahl - Fotozelle) zu einer Erkennung des Flammenfortschritts zu gelangen. Durch Anordnung von mehreren Lichtmeßstrecken sollte die Ausbreitung der Flammenspitzen verfolgt werden. Die hierzu erforderlichen Entwicklungs- und Erprobungsarbeiten wurden im Unterauftrag im Institut für Holzforschung der Universität München durchgeführt (siehe Anhang 4). Als Ergebnis mußte festgestellt werden, daß die verschiedenen verfolgten Ansätze nicht zu dem gewünschten Erfolg führten. Die Erkennung der Höhe der Flammenspitzen auf diesem Wege scheiterte an der mangelhaften Differenzierung durch die eingesetzten Lichtmeßstrecken.

4. Bau der Versuchsapparatur

Die Grundkonzepte der Versuchsanordnung zur konkreten Ausführung der Versuchsapparatur wurden in gemeinschaftlichen Konstruktionsarbeiten zwischen dem MPA NRW und der CSTB bemessen. Die Ergebnisse wurden der Gruppe der Laboratorien vorgestellt und entsprechend den dort erhaltenen Kommentaren modifiziert. Die endgültigen Werkstattzeichnungen auf der Basis dieser Ergebnisse wurden von der CSTB ausgeführt.

Die danach gebaute Versuchsanordnung besteht aus folgenden Teilen:

- Probenhalterwagen, in den die Proben zu einer Ecke zusammengestellt werden. Der Probenhalterwagen gestattet den Einbau von Probendicken von bis zu 20 cm. Die Proben werden gegen Anschläge gestellt und durch verschiebbare Halter festgeklemmt.

- Abzugshaube oberhalb des Probenhalterwagens; diese Abzugshaube ist aus Stahlblech gefertigt und innen mit Platten auf Vermiculite-Basis ausgekleidet, die aufgrund geringer Dichte eine geringe Wärmeeindringzahl aufweisen und auch gegen relativ hohe Brandbeanspruchung temperaturbeständig sind.

- An die Abzugshaube schließt ein Meßrohr an, in dem die entsprechenden Messungen (Temperatur, Sauerstoffverbrauch, Volumenstrom, Rauchdichte) ausgeführt werden.

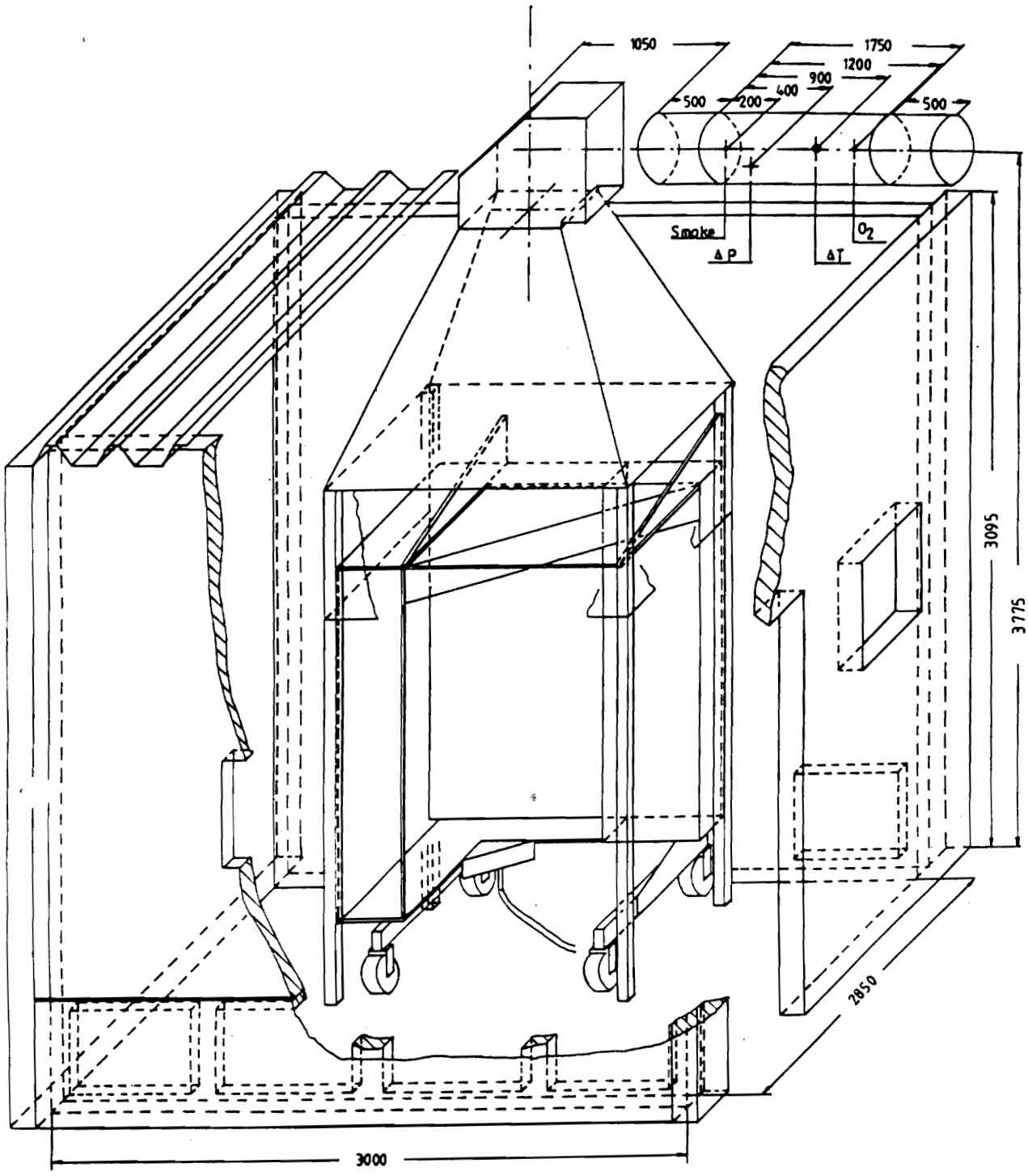
- Aus Arbeitsschutzgründen ist die Versuchsanordnung mit einem geschlossenen Raum eingehaust, der mit Zugangstüren zur Probenbeschickung bzw. Fenstern zur Beobachtung der Brandabläufe ausgerüstet ist. Der Versuchsraum hat definierte Zuluftöffnungen, die eine geringe Stömungsgeschwindigkeit gewährleisten.

- Die Beanspruchung wird mit einem dreieckförmigen Sandbettbrenner mit Kantenlängen von 250 mm erzeugt. Dieser Sandbettbrenner hat an der Unterseite in der Mitte eine Gaszufuhr. Das Gas strömt über die grobkörnige Sandfüllung ein und entnimmt der aus der Umgebung zuströmenden Luft den zur Verbrennung erforderlichen Sauerstoff. Die Flamme dieses Gasbettbrenners ist weich und instabil.

Eine isometrische Darstellung der ausgeführten Versuchsanordnung ist in Bild 1 wiedergegeben.

Die Versuchsapparaturen wurden im MPA NRW und in der CSTB als Prototypen hergestellt und aufgebaut.

Bild 1 - Versuchsanordnung



5. Versuche zur Inbetriebnahme

Nach Bau der Versuchsanordnung wurden erste Erprobungsversuche durchgeführt, in denen die Funktionstüchtigkeit der Probenbefestigung, des Brenners sowie der eingesetzten Meßtechnik erprobt wurden. In diesen Vorversuchen wurden die Niveaus der Meßsignale festgestellt, die bei den weiteren Versuchen zu erwarten waren.

Zur Erfassung der Meßdaten während der Versuche sollte eine Software entwickelt werden, die gleichzeitig die Auswertung und Darstellung der Versuchsergebnisse erlaubt. Für die ersten Versuchsserien wurde jedoch - da die Gemeinschaftsentwicklung noch nicht so weit fortgeschritten war - ein am Markt erhältliches Meßwerterfassungs- und -auswertprogramm eingesetzt, das auf die speziellen Bedürfnisse dieses Versuchs zugeschnitten wurde. Für die späteren gemeinschaftlichen Versuche wurde die vorgesehene Software durch die TNO zusammengestellt.

Im Zuge der Inbetriebnahme wurden auch die Meßmöglichkeiten zur Bestimmung des Volumenstroms (Durchflußkonstanten, Gleichmäßigkeit des Strömungsprofils im Abzugsrohr usw.) ermittelt. Ferner wurden die erforderlichen Abzugsgeschwindigkeiten ermittelt, die für verschiedene Materialien zum Abführen des Rauchs aus der Versuchseinrichtung erforderlich sind.

Nach Installation der Anlage wurde zunächst die Betriebsweise des Brenners sowie die daraus resultierende Wärmeflußdichte auf die Probekörper ermittelt. In verschiedenen Höhen und Abständen von der Ecke wurden Wärmeflußmessungen durchgeführt, die das von der EU vorgegebene Beanspruchungsniveau verifizierten. Um bei geringeren Flammenhöhen eine bessere Beobachtung der Flammenausbreitung zu erreichen, wurden entsprechende Untersuchungen auch mit Sandbettbrennern anderer Formen durchgeführt, mit denen die Beanspruchung variiert wurde. Die Ergebnisse dieser Untersuchungen sind im Abschlußbericht Teil 2 Abschnitt 3 zusammengestellt.

6. Versuche mit den Prototypen

Nach Aufbau und Erprobung der Versuchsanordnungen im MPA NRW und in der CSTB wurde eine Versuchsserie durchgeführt, bei der die Versuchsrandbedingungen variiert wurden. Diese Versuche hatten zum Ziel einerseits Vorinformationen über die zweckmäßigste Einstellung der Versuchsrandbedingungen zu schaffen, andererseits erste Informationen über die Wiederholbarkeit der Versuchsergebnisse und ihre Reproduzierbarkeit zu liefern.

- Bei den Versuchen wurden sowohl der Sandbettbrenner als auch die beiden zuvor beschriebenen Strahlungsbeanspruchungsquellen (Kammerbrenner und Oberflächenstrahler) eingesetzt.

- Bei einigen Versuchen wurde die Anordnung der Probekörper variiert.

- Bei einigen Versuchen wurde oberhalb der Proben eine Decke aus nichtbrennbaren Baustoffen eingesetzt, um einen Wärmestau und eine Ablenkung der Flammen zu erreichen.

- Bei einigen Versuchen wurde mit, bei anderen ohne eine dritte Wand gearbeitet, die die Versuchsanordnung zu einem U ergänzte.

Die Ergebnisse dieses Versuchsprogramms, das insgesamt 155 Versuche umfaßte, wurden den übrigen Laboratorien bzw. der Gruppe der Regulators vorgestellt (siehe Abschlußbericht Teil 2 Abschnitt 2).

Nach Diskussion der Ergebnisse wurden eine Reihe von konstruktiven Änderungen der Versuchsanordung sowie einige Änderungen im Hinblick auf die Versuchsbedingungen beschlossen. Es wurde entschieden, daß die endgültige Versuchsanordnung unter Verwendung des dreieckförmigen Sandbettbrenners erstellt werden sollte. Im Hinblick auf die Zuluft wurde entschieden, diese unterhalb des Probenträgerwagens einströmen zu lassen. Im Hinblick auf die Abzugshaube wurden eine einheitliche Form und Größe sowie die einheitliche Ausführung der Isolierung beschlossen. Ferner wurde festgelegt, daß das an die Abzugshaube anschließende Abzugsrohr, in dem die Meßtechnik untergebracht wird, in allen beteiligten Prüfstellen einheitlich ausgeführt werden sollte, um hierdurch Unterschiede der Versuchsergebnisse zu verringern.

Ferner wurde entschieden, daß zur Kalibrierung vor jedem Versuch sowie zur Schaffung einer Basislinie für die durchzuführenden Messungen der Energiefreisetzungsrate und der Abgastemperatur ein zweiter Brenner gleicher Bauart in der Versuchsanordnung angeordnet werden sollte. Dieser Brenner sollte sich gegenüber der mit den Proben ausgekleideten Ecke kurz unterhalb der Abzugshaube befinden, damit die Proben selbst hierdurch nicht beansprucht würden. Um eine Strahlungsvorbeanspruchung zu vermeiden, wurde der Brenner außerdem mit einer Abschirmung aus einer Faserzementplatte versehen.

7. Bau der endgültigen Versuchsapparaturen

Unter Einbeziehung der beschlossenen konstruktiven Änderungen wurden die endgültigen Werkstattzeichnungen der Versuchsapparatur von RUG unter Beiziehung des MPA NRW angefertigt. Auf der Basis dieser Werkstattzeichnungen wurden Angebote zur Herstellung von weiteren Apparaturen eingeholt.

In der Folgezeit wurden die weiteren Apparaturen in den 7 weiteren Laboratorien beschafft und aufgebaut. Im MPA NRW und in der CSTB wurden die vorhandenen Versuchsapparaturen so geändert, daß sie den beschlossenen konstruktiven Details genügten. Nach dem Bau der weiteren Versuchseinrich-

tungen, ihrem Anschluß an die vorhanden Ver- und Entsorgungseinrichtungen sowie ihrer Inbetriebnahme wurden in den beteiligten Laboratorien erste Tastversuche durchgeführt, um mit der Arbeitsweise der Versuchsapparatur vertraut zu werden und um die Kalibriermöglichkeiten zu erproben.

Auf der Basis der Erfahrungen aus den Vorversuchen wurden ein erster Rohentwurf für eine Prüfnorm einschließlich eine Verfahrensanweisung zur Durchführung der Versuche erstellt, die als Grundlage der später durchgeführten Rundversuche dienten.

8. Rundversuche

Zur Feststellung der Reproduzierbarkeit und der Wiederholbarkeit der Versuchsergebnisse wurde ein umfangreiches Rundversuchsprogramm zwischen den beteiligten Laboratorien organisiert. Darüber hinaus wurde die Möglichkeit geschaffen, daß weitere Laboratorien an diesen Rundversuchen teilnehmen konnten.

Um die ordnungsgemäße Funktion der Versuchseinrichtungen und insbesondere der Meßtechnik zu überprüfen, sah das Versuchsprogramm vor, daß zunächst in jedem Laboratorium ein Kalibrierversuch mit einer definierten Menge Methanol durchgeführt wurde. Ferner wurden jeweils einige Versuche an Holzspanplatten und Weichfaserdämmplatten durchgeführt, deren Ergebnisse dem koordinierenden Laboratorium (TNO) zur Analyse vorgelegt wurden. Nach Prüfung der Ergebnisse dieser ersten Versuchsreihe erhielten die Laboratorien, die innerhalb einer realistischen Bandbreite liegende Versuchsergebnisse erzielt hatten, grünes Licht für die Durchführung der weiteren Rundversuche (weitere 28 Materialien). Die Rundversuche wurden an insgesamt 30 Materialien durchgeführt. Versuchsdurchführung und Details wurden entsprechend dem o.a. Normentwurf als Arbeitsanweisung ausgeführt.

Die Versuche wurden bis September 1997 abgeschlossen und über den Koordinator (TNO) an die mit der Auswertung beauftragte Prüfstelle (VTT) geleitet. (Die Ergebnisse der im MPA NRW durchgeführten Versuche sind dem Abschlußbericht Teil 3 zu entnehmen). Dort erfolgte eine statistische Auswertung gem. ISO 5725. Die Ergebnisse der Rundversuche sowie ihre statistische Auswertung sind in Anhang 1 zusammengestellt. Aus Termingründen war es nicht möglich, die statistische Auswertung soweit auszuführen, daß auch Ursachen für Ausreißer erkannt wurden und diese ausgeschlossen werden konnten. Die statistische Auswertung in Anhang 1 bewertet die gewonnenen statistischen Daten der zur Reproduzierbarkeit und Wiederholbarkeit auf Vergleich mit den Ergebnissen anderer international genormter Prüfverfahren. Eine weitere Kommentierung der statistischen Auswertung ist in dem der Gruppe der Regulators vorgelegten Dokument Anhang 2 enthalten.

Insgesamt kommt die statistische Bewertung zur folgenden Schlußfolgerungen:

Im Hinblick auf die zu messende Zeit bis zur Entzündung, im Hinblick auf die Energiefreisetzung und Energiefreisetzungsrate sowie im Hinblick auf die Ergebnisse der Temperaturmessung liefert der SBI-Test zufriedenstellende bis gute Werte für die Wiederholbarkeit und Reproduzierbarkeit. Im Hinblick auf die Flammenausbreitung wird festgestellt, daß die Wiederholbarkeit für horizontale und vertikale Flammenausbreitung zufriedenstellend ist. Im Hinblick auf die Reproduzierbarkeit der Messung der vertikalen Flammenausbreitung werden jedoch Verbesserungen für erforderlich gehalten, wenn dieser Wert in die Klassifizierung eingeht. Für das brennende Abtropfen bzw. Abfallen brennender Teile werden Wiederholbarkeit und Reproduzierbarkeit als akzeptabel bewertet.

7. Zusammenfassung

Das zur Bewertung des Brandverhaltens von Baustoffen der Euro-Klassen B, C und D vorgesehene SBI-Prüfverfahren wurde im Rahmen einer Gemeinschaftsentwicklung entworfen und erprobt.

Nach Bau von zwei Prototypen wurden Änderungen zur Verbesserung der Handhabbarkeit, der Belüftung, der Meßtechnik und des Arbeitsschutzes beschlossen. Die Ergebnisse wurden beim Bau weiterer Versuchsapparaturen berücksichtigt.

Nach Fertigstellung der weiteren Versuchsapparaturen wurde in den beteiligten Laboratorien, zu denen eine Reihe externer Laboratorien hinzukam, ein umfangreiches Rundversuchsprogramm durchgeführt, das insgesamt 30 Materialien umfaßte. Die Ergebnisse des Rundversuchsprogramms wurden statistisch ausgewertet. Die Ergebnisse weisen eine im wesentlichen befriedigende Reproduzierbarkeit und Wiederholbarkeit einerseits sowie eine ausreichende Möglichkeit zur Unterscheidung des Brandverhaltens der in Frage kommenden Bauprodukte aus.

Auf der Basis dieser Auswertung wurde von der Gruppe der Regulators die Empfehlung an den Ständigen Ausschuß Bauwesen bei der EU-Kommission gegeben, die Entwicklungsarbeit als abgeschlossen anzunehmen und der europäischen Normenorganisation CEN den Auftrag zur Normung des Prüfverfahrens zu erteilen.

Die noch offen stehenden Versuche zur Schaffung einer Datenbank für eine Vielzahl weiterer Materialien ist in die Wege geleitet.

Anhang 1

Ergebnisse der Rundversuche

Development of the Single Burning Item Test
- Results of the SBI Round Robin tests -

October 7, 1997

TABLE OF CONTENTS

SUMMARY

The objective of the round-robin tests was to provide:

a. confirmation of the ability of the prototype to measure all the requested characteristics;
b. confirmation of the reproducibility and repeatability of the test procedure.

This confirmation has been looked for in the results of three replicate tests on thirty selected materials/products carried out in fifteen laboratories.

The reproducibility and repeatability of the final test method depends on the choice of the quantities used to evaluate the requested characteristics.

Based on the round robin results the SBI may be considered to be capable to measure all requested characteristics, with reproducibilities and repeatabilities between acceptable and good in comparison to results that can be expected from other well accepted fire tests.

Only the reproducibility of the smoke production measurement must be improved. It is considered to be possible to do this by incorporating appropriate calibration procedures and additional instructions. The reproducibility of the observation of time to reach certain vertical flame spread should be improved too if this quantity is used in the evaluation. However, there are alternative options to the vertical flame spread.

REFERENCES

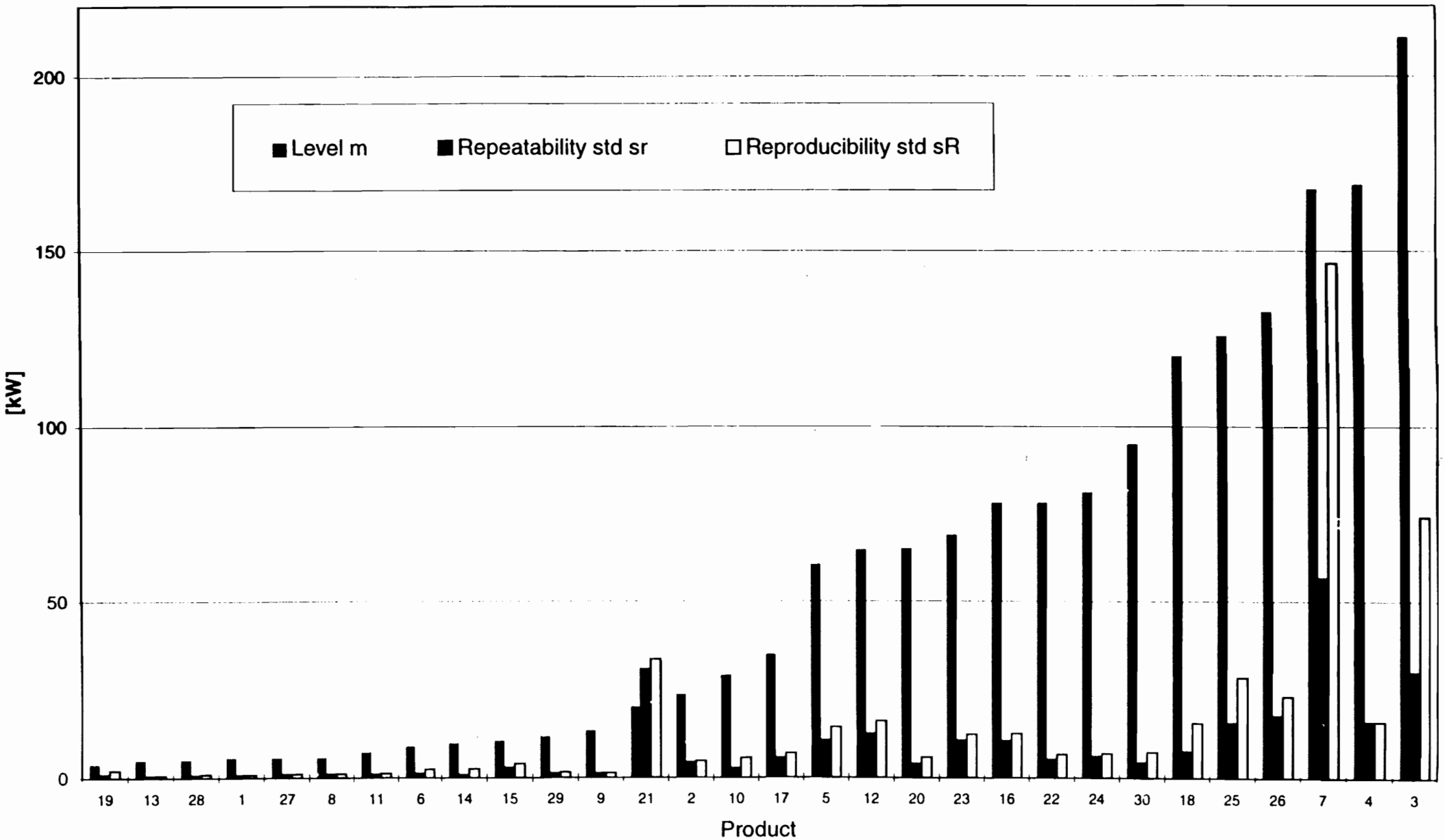
1. EN yyyy, "Reaction to fire tests on building products - All building products excluding floorings - exposed to the thermal attack by a single burning item ("SBI test")", draft standard June 26, 1997.
2. SBI-RR 16 **Rev.2**, "Mounting of specimens in the SBI Round Robin", draft document June 26, 1997.
3. SBI-RR 13, "Statistical analysis of interlaboratory tests" (a short description of the method for statistical analysis of the data in accordance with ISO 5725, 1994).

SYMBOLS

cum(ΔT):	integral of ΔT over the total test period
ΔTmax:	maximum of temperature rise
RHRmax:	maximum of rate of heat release measured by oxygen depletion
RSPmax:	maximum of rate of smoke production
THR:	total heat release, equal to the integral of the rate of heat release over the total test period
TSP	total smoke production, equal to the integral of the rate of smoke production over the total test period
t_{drip}:	time of falling of first flaming droplet/particle
$t_{drip15s}$:	time of falling of first flaming droplet/particle that remains burning 15 seconds
t_{flow}:	time of falling of first flow of droplets/particles.
tign(visual):	time of visual observation of the first flaming combustion
tign(Δ5kW):	time RHR rise exceeds 5 kW
tign(Δ3K):	time ΔT rise exceeds 3 K
t_{y1000}, t_{y1250}, t_{yedge}:	time for vertical flame spread to reach reference lines at heights of 1000 mm, 1250 mm and sample edge)
t_{x250}, t_{x350}, ..., t_{xedge}:	time for lateral flame spread to reach reference lines at distances of 250 mm, 350 mm, and every additional 100 mm until the sample edge

ANNEX 5 TABLES AND GRAPHS OF ANALYSED PARAMETERS

max RHR in kW


Level m
Repeatability std sr
Reproducibility std sR
[kW]
0
50
100
150
200
19 13 28 1 27 8 11 6 14 15 29 9 21 2 10 17 5 12 20 23 16 22 24 30 18 25 26 7 4 3
Product

1. INTRODUCTION

The decision of September 9, 1994 of the European Commission has stated that the reaction to fire behaviour of construction products, excluding floor coverings, would be classified with a Euroclasses system that uses four tests, one of which is the Single Burning Item (SBI) test.

Upon presentation of the results obtained with pre-prototypes of the test apparatus, the Commission, after the meeting of the Standing Committee of October 7, 1996, has given a green light for implementing the next step of the development of the SBI test, the Round Robin tests.

To perform the actual Round Robin tests, two previous steps of the programme had to be finalised first: step 3,"Development of software" and step 6, "Construction, commissioning and calibration of further prototypes". These steps were finalised in June 1997; they are reported elsewhere.

This report presents a summary of the results of the Round Robin analysis, needed to discuss the ability of the SBI to measure all the requested characteristics, as well as the reproducibility and repeatability of the test procedure.

2. ORGANISATION OF THE ROUND ROBIN

Information about organisation of the round robin has been presented in three documents: the "SBI Round Robin, General information document" (ref. 1), the draft standard (ref. 2) and a mounting document (ref.3).
The first document contains information about the participating laboratories, the test facility used, the data to be recorded and the way of processing and exchanging the data and other items. The draft standard (ref. 2) contains the procedures for calibration and testing, the data to be measured or observed and the processing of data. For the mounting procedure it refers to ref. 3.

3. PARTICIPATING LABORATORIES

Twenty laboratories declared their willingness to participate in the round-robin (RR) tests. Fifteen of these laboratories were able to complete the pre round robin tests and calibrations. These fifteen laboratories all succeeded to finalise the round robin tests before September 19. Taken into account the efforts to prepare the test facilities and the amount of tests that had to be done in only 11 weeks including the summer holidays period, this should be considered an excellent result.
The list of laboratories that reported their round robin tests is given in annex 1. The results in this report are presented in an anonymous way; the laboratories are coded L01 - L20. Serial list numbers in relations to laboratories in tables are sometimes used for convenience; these list numbers are different from the confidential laboratory codes.

4. PRODUCTS/MATERIALS TESTED

The list of 30 products used in the round-robin is given in annex 2. In this report the products are coded M1 - M30.
In the round-robin each participant has carried out 90 tests: 3 tests each on all 30 products in the list.

5. ROUND ROBIN RESULTS AND ANALYSIS

5.1 General remarks

5.1.1 The amount of measured and observed quantities per test, and the amount of tests were very large. In combination with a very tight time schedule this did not allow the laboratories to check the results of their tests on (obvious) inconsistencies. This led to the rather drastic policy to exclude questionable data from the analysis, without trying to correct the data by consultation of the testing laboratories involved.

5.1.2 The assessment of the repeatability and reproducibility of a quantity in terms of good, reasonable, acceptable, questionable, not acceptable, is always relative to the result that can be expected from the same quantity in other well accepted fire tests.
The SBI is an intermediate scale test in which mechanical behaviour of the test specimens is of importance, which leads to higher values for relative repeatability and reproducibility. This in contradiction to small scale tests (e.g. the Cone calorimeter test of which recent round robin data are available and presented in annex 3).

5.1.3 The quantities analysed to evaluate the requested characteristics have been chosen during the development of the prototype and the test procedure. Some of the quantities were selected on the basis that they could probably replace visual observations, to prevent the influence of personal interpretation.

5.1.4 The majority of the products in the round robin show a moderate or small reaction to fire. Nine products had a small maximum rate of heat release (< 10 kW) and only six products had a large one (> 100 kW).

5.1.5 The results of 2 out of the 30 materials tested, M7 and M21, show variations in results in such a way, that the test conditions in these tests (e.g. the way of mounting) were judged to be very probably unequal. The results for these products are therefore presented as such, but are left out of the presentation of the overall performance of the 30 products. Differences in test conditions may have resulted in differences in results for other materials too. It was not possible to investigate this further during the analysis.

5.1.6 In general, relative repeatability and reproducibility are poor for very small values of the quantity concerned. This also holds for the present Round Robin results and should be taken into account when interpreting the data.

5.1.7 The Euroclasses system requires five parameters to be measured by the SBI. Each of the parameters has two or three required levels of performance:

1.	Heat release	"limited" HR (class C) "acceptable" HR (class D)
2.	Smoke production	"very limited" SP (class B) "limited" SP (class C and D)
3.	Spread of flame	"practically no" SF (class B) "very limited" SF (class C) "limited" SF (class D)
4.	Time to ignition	"limited" Ignitability (class C) "acceptable" Ignitability (class D)
5.	Flaming droplets/particles	"no" FDP (class B) "very limited" FDP (class C) "limited" FDP (class D)

5.1.8 The results of the analysis for these five parameters are given below. Tables and graphs on which the results are based, are presented in annex 4 and 5.

5.1.9 Annex 4, "Tables and graphs" contains the major analysis results:
- 30 pages with summary results of 30 products;
- graphs with summary results of several measured quantities, in ranking order;
- some additional graphs and tables.

5.1.10 The time available to prepare the Round Robin did not allow for additional calibrations and local checks of the SBI test facilities. Additionally, the time available for analysis and reporting, 3 weeks, was not long enough to optimize the quantities used.
Therefore the repeatability and reproducibility results reached here must be considered as safe estimates of the results that can be obtained with this test method.

5.2 Heat release

5.2.1 The quantities measured and calculated in all tests to evaluate the heat release are:
- maximum of rate of heat release measured by oxygen depletion: RHRmax;
- maximum of temperature rise: ΔTmax;
- total heat release, equal to the integral of the rate of heat release over the total test period: THR;
- integral of ΔT over the total test period: cum(ΔT).

5.2.2 Comparing results of RHR measurements and ΔT measurements, it is very important to know whether the contribution of the burner is incorporated, or only the contribution of the sample. Incorporating the burner, which is burning on a continuous level, gives an important improvement of the relative repeatability and reproducibility results, especially at low contribution level of the samples.

In the RHR results the effect of the burner is subtracted. This is not the case in the ΔT results. The effect of the burner cannot be eliminated from the ΔT results easily, because this effect is time dependent. Therefore, where needed for comparison between RHR and ΔT results, the burner contribution is added to the RHR of the sample giving RHR_{total}.

5.2.3 The volume flow of the exhaust gases was fixed within limits at the start of the test. During the test however the volume flow may vary when temperature rises, dependent on the type of the exhaust system used in the concerning laboratory.
The RHR measurement method includes a compensation for changes in volume flow; the ΔT measurement does not. Therefore some additional analysis has been carried out on the quantities: ΔT multiplied by the volume flow (ΔTxVfl) and the integral value over the test period (cum(ΔTxVfl)), to investigate the possibility to improve the results based on ΔT.

5.2.4 The relative repeatabilities (s_r/m), the relative reproducibilities (s_R/m) and their mean values over 28 products are:

- RHRmax (without burner): s_r/m varies between 4.6 % and 27.6 %, with a mean value of 13.4 %
  s_R/m 7.6 % - 55.3 %, mean value 19.3 %.
- ΔTmax (with burner): s_r/m 1.6 % - 15.5 %, mean value 6.4 %
  s_R/m 8.1 % - 29.0 %, mean value 14.3 %.
- $RHRmax_{total}$ (with burner): s_r/m 1.7 % - 13.2 %, mean value 6.0 %
  s_R/m 1.9 % - 30.8 %, mean value 8.7 %.
- THR (without burner): s_r/m 5.2 % - 40.7 %, mean value 16.8 %
  s_R/m 6.8 % - 59.9 %, mean value 25.5 %.
- cum(ΔT) (with burner): s_r/m 1.6 % - 13.4 %, mean value 4.1 %
  s_R/m 8.2 % - 18.6 %, mean value 12.2 %.
- THR_{total} (with burner): s_r/m 1.4 % - 12.2 %, mean value 3.7 %
  s_R/m 2.5 % - 14.6 %, mean value 5.8 %.

5.2.5 Comparing the relative s_r and s_R of RHR and ΔT related quantities including the burner effect, we find that the RHR related quantities have lower values. This holds for both the maximum values and the integral values. Also see the graphs in annex 5.
Taking into account the effect of the observed variations in volume flow, the values of relative s_r and s_R become smaller, with an improvement of about 1 % in s_r/mean and 3 % in s_R/mean (these estimates are based on analysis of only 11 products). For cum(ΔT) this effect is somewhat smaller, leading to mean values of s_r/mean and s_R/mean of 3.6 % and 10.4 % respectively.

5.2.6 The round robin results show the capability to measure the heat release with a good repeatability and reasonable reproducibility.
The Euroclasses system demands two levels of performance for heat release in the SBI to

be set (for classes C and D). This is possible with the current SBI test.

5.3 Smoke production:

5.3.1 The quantities measured and calculated in all tests to evaluate the smoke production are:
- maximum of rate of smoke production: RSPmax;
- total smoke production, equal to the integral of the rate of smoke production over the total test period: TSP.

5.3.2 The results of RSP measurements contain the contribution of the burner. This is not an important factor in this measurement.

5.3.3 More than half of the tests showed a drift in the equipment during the test, most probably caused by the optics getting dirty. The influence of the drift on RSPmax is considered to be rather small; the influence on TSP however can be large. Therefore, all tests were taken into account in the statistical analysis of RSP. The s_r and s_R results of TSP should be taken as an indicative and (very) safe approximation.

5.3.4. The relative repeatabilities (s_r/m), the relative reproducibilities (s_R/m) and their mean values over 28 products are:
- RSPmax: s_r/m varies between 6.6 % and 72.9 %, mean value 20.7 %
  s_R/m 18.9 % - 114.2 %, mean value 51.2 %.
- TSP: s_r/m 8.1 % - 78.4 %, mean value 22.4 %
  s_R/m 23.0 % - 87.8 %, mean value 53.4 %.

5.3.5. The round robin results show the capability to measure the smoke production with a reasonable repeatability. The reproducibility however is not as good as needed.
The general equipment used for smoke measurements in the SBI is identical to the equipment used in many other fire tests for a long time, which is why no additional calibration was requested in the round robin. The conclusion now is that additional calibration and more detailed instructions are needed, also because no widely accepted alternative methods are available.

The Euroclasses system demands two levels of performance for smoke production in the SBI to be set (for classes B and C/D). There should be no problem after incorporating appropriate calibration procedures and additional instructions.

5.4 Ignition:

5.4.1. The quantities measured and calculated in all test to evaluate the time to ignition are:
- visual observation of the first flaming combustion: tign(visual);
- RHR rise exceeding 5 kW: tign(Δ5kW);
- ΔT rise exceeding 3 K: tign(Δ3K).

5.4.2 Ignition is defined as "initiation of combustion". The three methods used to evaluate the ignitability will report ignition times that are longer than the actual ones, because a visually observable flame, a small heat release rate and a small temperature rise, if any, will all appear some time after the initiation of combustion. In addition, the visual observation of the first flaming combustion may be difficult because of the burner flames nearby or combustion within the specimen structure.

5.4.3 The limit values for rise of temperature (3 K) and heat release (5 kW) has been set as a first estimate of a useful value. No optimalisation has been performed due to lack of analysis time.
The drift in the temperature value, without ignition of the product, (nearly) leads to exceeding the 3K limit during the test, which prevents the limit to be lower. The variations in burner output and the noise in the RHR signal prevent a very low RHR rise value. Higher values for both quantities lead to slower response times.

5.4.4 The mean value for the time to ignition is not a meaningful quantity in several tests reporting no ignition. Therefore the calculation of mean values for rel.s_r and rel.s_R is carried out on the 22 products reporting ignition. The results of the other products were analysed qualitatively.

5.4.5 The relative repeatabilities (s_r/m), the relative reproducibilities (s_R/m) and their mean values over 22 products are:

- tign(visual): s_r/m 9.5 % - 31.0 %, mean value 19.6 %
  s_R/m 12.1 % - 48.2 %, mean value 29.9 %.

- tign(Δ5kW): s_r/m 5.7 % - 72.6 %, mean value 17.7 %
  s_R/m 17.0 % - 155.3 %, mean value 42.6 %.

- tign(Δ3K): s_r/m 6.4 % - 36.1 %, mean value 11.8 %
  s_R/m 9.0 % - 80.6 %, mean value 22.3 %.

5.4.6 Comparing the relative s_r and s_R of the tign values, we find the lowest values for tign(Δ3K). The s_R/m value for tign(Δ5kW) is the highest one. In absolute values this is different. The tign(Δ5kW) values are equal to or smaller than the tign(visual) ones, the tign(Δ3K) values are higher. Also see the graph in annex 5.

5.4.7 The time to ignition values based on ΔRHR=5kW were equal to or slightly smaller than the time to ignition by visual observation for values of tign(visual) below 100 seconds. For products with higher tign(visual) values, the tign(Δ5kW) values are much smaller. For the tign(Δ3K) values the opposite holds: Especially for tign(visual) values above 100 seconds, the tign(Δ3K) values in most cases are much larger than the tign(visual) ones.

5.4.8 The chosen limit value for rise of heat release was probably not the optimum. Other values between 5 and 10 kW could be more appropriate considering repeatability, reproducibility and accordance with the visual observations.

5.4.9 The round robin results show the capability to measure the ignition time with a good repeatability and a reasonable or acceptable reproducibility. For most products the reproducibility is reasonable.
The Euroclasses system demands two levels of performance for time to ignition (for classes C and D). This is very well possible with the current SBI test.

5.5 Spread of flame:

5.5.1. The quantities measured in all test to evaluate the spread of flame are:
- time for vertical flame spread to reach reference lines at heights of 1000 mm, 1250 mm and sample edge): t_{y1000}, t_{y1250}, t_{yedge};
- time for lateral flame spread to reach reference lines at distances of 250 mm, 350 mm, and every additional 100 mm until the sample edge: t_{x250}, t_{x350}, ..., t_{xedge};
- farthest lateral flame spread to reach between two reference lines (at distances of 250 mm, 350 mm, and every additional 100 mm until the sample edge).

5.5.2 An additional option to evaluate the spread of flame is the speed of increase of the rate of heat release. It takes considerable time to select an optimum quantity for this evaluation. It was not possible to do this in the reported analysis.

5.5.3 The relative repeatabilities (s_r/m), the relative reproducibilities (s_R/m) and their mean values were calculated for t_{yedge} t_{x250}, t_{x350}:

- t_{yedge}: s_r/m 6.9 % - 40.8 %, mean value 18.2 %
  s_R/m 13.3 % - 131 %, mean value 51.4 %.
- t_{x250}: s_r/m 9.2 % - 41.5 %, mean value 22.1 %
  s_R/m 15.5 % - 135 %, mean value 39.3 %.
- t_{x350}: s_r/m 7.1 % - 28.7 %, mean value 18.9 %
  s_R/m 15.7 % - 74.9 %, mean value 35.2 %.

These values hold for t_x or t_y times taken from the time of ignition of the burner, this in contradiction to some tables in the annex 4.

5.5.4 Comparing the relative s_r and s_R of vertical flame spread and lateral flame spread, the lateral flame spread reproducibilities are smaller. The repeatability values are nearly equal.

5.5.5 The total flame spread was analysed by counting the amount of tests in which the farthest lateral flame spread reached between two given reference lines (a "region"; e.g. the second region is between the x-lines at 250 and 350 mm). The farthest lateral flame spread of different tests will ideally be in one or, due to scatter in results near the reference lines, two adjacent regions. The results are presented in annex 5.
Only for five out of the 30 products tested, there is more than one observation outside the two adjacent regions. For one product the flame spread seems to be rather unpredictable

(M03). For the other four products less than 30 % of the observations is outside the two regions.

5.5.6 The round robin results show the capability to measure the flame spread with a reasonable repeatability for both flame spread directions and reasonable reproducibility for lateral flame spread. The reproducibility of vertical flame spread needs to be improved when this quantity is used to evaluate flame spread.
The Euroclasses system demands three levels of performance for flame spread in the SBI to be set (for classes B, C and D). This is possible with the current SBI test. For example by choosing levels of farthest lateral flame spread and/or times for certain reference lines to be reached.

5.6 Flaming droplets/particles

5.6.1. The quantities measured in all test tc evaluate falling flaming droplets and/or particles are:
- time of falling of first flaming droplet/particle t_{drip};
- time of falling of first flaming droplet/particle that remains burning 15 seconds $t_{drip15s}$;
- time of falling of first flow of droplets/particles t_{flow}.

5.6.2 The mean value for the time of falling of the first droplet/particle is not a meaningful quantity when incorporating tests not reporting any falling flaming droplet/particle. Due to the fact that for the majority of products, there were some tests without reported falling flaming droplet/particle, only a approximation can be given of s_r/m and s_R/m for t_{drip}.
For the quantities $t_{drip15s}$ and t_{flow} the calculation of s_r/m and s_R/m values was not useful.

5.6.3 The relative repeatability (s_r/m), the relative reproducibility (s_R/m) and the mean value was calculated for t_{drip}: s_r/m mean value not exceeding 30 %
s_R/m mean value not exceeding 50 %.

These values hold for t_{drip} times taken from the time of ignition of the burner, this in contradiction to some tables in the annex 4.

5.6.4 The occurrence of falling of the first flaming droplet/particle and of falling of the first flow of droplets/particles was counted. The falling of droplets/particles that remain burning during 15 seconds has not been analysed since the observation was very difficult near the burner.
The results should be compared to expected results. No further analysis could be carried out in time.

5.6.5 The round robin results show the capability to measure the falling of flaming droplets and/or particles, with an acceptable repeatability and reproducibility for t_{drip}.
The Euroclasses system demands three levels of performance for flaming droplets/ particles in the SBI to be set (for classes B, C and D). This is possible with the current SBI test. For example by choosing levels of occurrence (one droplet/particle; flow of droplets/particles) and/or times for the occurrence to appear.

PARTICIPANTS REPORTING ROUND-ROBIN RESULTS			
	Laboratory	Country	Contact person
1	CSTB	F	Mr. Braine Bonnaire
2	DIFT	DK	Mrs. Messerschmidt
3	FRS	UK	Mr. Shaw
4	LSF	I	Mr. Messa
5	MPA	D	Mr. Klingelhofer / Mr. Rademacher
6	RUG	B	Mr. Vandevelde / Mr. Sette
7	SP	S	Mr. Sundstrom/ Mr. Van Hees
8	TNO	NL	Mr. Van Mierlo / Mr. Janse
9	VTT	FI	Mr. Mikkola
10	Armstrong	USA	Mr. Hunsberger
11	Bayer	D	Mr. Wittbecker / Mr. Muller
12	Hoechst	D	Mr. M. Mitzlaff
13	IBS	A	Mr. Moser
14	Isover	F	Mrs. N. Rose / Mrs. K. Chartier-Richard
15	Knauf	F	Mr. J. Sanchez
16	LNE	F	Mr. Sainrat
17	MA39-VFA	A	Mr. C. Pohn
18	MFPA	D	Mr. W. Rosler
19	Rockwool	DK	Mr. Clausen
20	WFRC	UK	Mr. P. Briggs

PRODUCTS / MATERIALS TO BE TESTED

(Remark: Products are not fire retardant treated unless specified otherwise (with 'FR'))

Code	Product name	Thickness [mm]	Density [kg/m^3]	Surface weight [g/m^2]
M01	Paper-faced gypsum plasterboard	13	700	
M02	FR PVC	3	1180	
M03	FR extruded polystyrene board	40	32	
M04	PUR foam panel with alu foil faces	40	PUR: 40	
M05	Mass timber (pine), varnished	10	380	
M06	FR chip board	12	780	
M07	FR PC panel, 3-layered	16	175	
M08	Painted paper-faced gypsum plaster board	13	700	Paint: 145
M09	Paper wall covering on gypsum plasterboard	13	700	Paper: 200
M10	PVC wall carpet on gypsum plasterboard	13	700	PVC: 1500
M11	Plastic-faced steel sheet on mineral wool	0.15 + 1 + 50	Wool: 160	
M12	Mass timber (spruce), unvarnished	10	450	
M13	Gypsum plasterboard on polystyrene	13 + 100	700; 20	
M14	Phenolic foam	40		
M15	Intumescent coat on particle board	12	700	Paint: 500
M16	Melamine faced MDF board	12	MDF: 750	Melamine: 120
M17	PVC water pipe	diam.: 32; d: 2		
M18	PVC covered electric cables			
M19	Unfaced rockwool	50	145	
M20	Melamine faced particle board	12		
M21	Steel clad EPS sandwich panel	0.5 + 100	EPS: 20	
M22	Ordinary particle board	12	700	
M23	Ordinary plywood (birch)	12	650	
M24	Paper wall covering on particle board	12	700	Paper: 200
M25	Medium density fibreboard	12	700	
M26	Low density fibreboard	12	250	
M27	Gypsum plaster board/FR PUR foam core	13 + 87	PUR: 38	
M28	Acoustic mineral fibre tiles	18	Wool: 220	
M29	Textile wall paper on CaSi board	CaSi:10	CaSi: 875	Covering: 400
M30	Paper-faced glass wool	100	18	90

Annex 3

VTT TECHNICAL RESEARCH CENTRE OF FINLAND TELEFAX

Attention : Rudolf van Mierlo +31 152 843 984

From : Esko Mikkola

Date : 6.10.1997

Number of pages (incl. this page) : 1

Message : SBI-Round Robin

Dear Rudolf van Mierlo,

Concerning comparitive repeatability and reproducibility results from earlier studies I can present the following (Note that the results given below are based on ISO 5725/1986 version! I have devided the results by 2,8 to get to the standard deviations; there are some minor differencies between the 1986 and present 1994 version but the below given results should be well comparable with the SBI results):

1. From the latest version on cone calorimeter (ISO CD 5660-1 from ISO TC92/SC1, 1997). (Note that the CD ballot gave (this year) 17 positive votes and no negative votes (one abstain), which means that the precision data were felt acceptable.)

Parameter	Range	Repeatability stand.deviation	Reproducibility stand deviation
RHR max	70-1100 kW/m^2	5,1 - 11 %	7,0 - 36 %
THR	5-700 MJ/m^2	2,8 55 %	3,7 - 87 %
Ignition	7-150 s	5,4 - 25 %	10 - 46 %

2. Smoke (average specific extinction area, m^2/kg, can be compared with the total smoke production) from ISO TC92 SC1/WG5 Round Robin (1991-1992) in connection to the cone calorimeter. This method is using laser. The method is dynamic and thus can be compared to SBI.

Product type	Repeatability stand.deviation	Reproducibility stand deviation
Polystyrene, PVC	6 - 7 %	16 - 21
Plywood	about 20 %	about 40 %
Gypsum board, FR wood	about 60 %	about 100 %

Regards,

Esko Mikkola

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ANNEX 4 TABLES OF THIRTY PRODUCTS

PRODUCT M01: Paper-Faced Gypsum Plasterboard

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	12	12	12
Laboratories with no erroneous data	10	10	12	11	10	9	7	10	12	9	6	6
Outliers detected in the stat. tests	0	0	1	0	1	0	2	1	0	0	0	0
Laboratories used in the stat. anal.	10	10	11	11	9	9	5	9	12	9	6	6
Level estimate m	5.6 kW	2.9 MJ	31.3 K	35131 Ks	0.12 m^2/s	106.0 m^2	57.6 s	51.7 s	336 s	535 s	806 s	489 s
Repeatability std s_r	0.8 kW	1.2 MJ	0.6 K	864 Ks	0.02 m^2/s	20.9 m^2	6.1 s	4.7 s	49 s	72 s	145 s	57 s
Reproducibility std s_R	0.8 kW	1.3 MJ	2.7 K	3158 Ks	0.05 m^2/s	42.9 m^2	22.1 s	10.2 s	72 s	83 s	166 s	116 s
Relative repeatability std s_r / m	14.8 %	40.3 %	1.8 %	2.5 %	14.6 %	19.7 %	10.5 %	9.0 %	14.5 %	13.5 %	18.0 %	11.7 %
Relative reproducibility std s_R / m	14.8 %	44.4 %	8.7 %	9.0 %	40.3 %	40.5 %	38.4 %	19.6 %	21.4 %	15.5 %	20.6 %	23.7 %
For the confidence level of 95%												
Repeatability limit r	2.4 kW	3.4 MJ	1.6 K	2443 Ks	0.05 m^2/s	59.0 m^2	17.2 s	13.2 s	138 s	205 s	411 s	162 s
Reproducibility limit R	2.4 kW	3.7 MJ	7.7 K	8932 Ks	0.14 m^2/s	121.4 m^2	62.5 s	28.7 s	203 s	234 s	470 s	328 s
Relative repeatability limit r / m	42.0 %	114.0 %	5.2 %	7.0 %	41.2 %	55.7 %	29.8 %	25.6 %	41.0 %	38.3 %	51.0 %	33.2 %
Relative reproducibility limit R / m	42.0 %	125.5 %	24.7 %	25.4 %	113.9 %	114.5 %	108.6 %	55.5 %	60.4 %	43.7 %	58.3 %	67.0 %

THR : **LAB01 STRAGGLER** according to Cochran's test for within laboratory variance.
ΔT : **LAB12 OUTLIER** according to Cochran's test for within laboratory variance.
cum. ΔT : **LAB12 STRAGGLER** according to Cochran's test for within laboratory variance.
RSP : **LAB16 OUTLIER** according to Cochran's test for within laboratory variance.
t_{ign} (vis.). **LAB10** and **LAB14 OUTLIERS** according to Cochran's test for within laboratory variance.
t_{ign} (5kW). **LAB07 OUTLIER** according to Cochran's test for within laboratory variance.

PRODUCT M02: FR PVC

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	12	12	12
Laboratories with no erroneous data	10	10	11	11	10	10	11	10	12	9	6	6
Outliers detected in the stat. tests	0	0	0	0	0	0	2	0	0	0	0	0
Laboratories used in the stat. anal.	10	10	11	11	10	10	9	10	12	9	6	6
Level estimate m	23.9 kW	12.6 MJ	39.6 K	39596 Ks	3.2 m^2/s	1486 m^2	33 s	47 s	336 s	535 s	806 s	489 s
Repeatability std s_r	4.4 kW	1.7 MJ	3.2 K	1582 Ks	0.6 m^2/s	190 m^2	8 s	13 s	49 s	72 s	145 s	57 s
Reproducibility std s_R	4.8 kW	2.0 MJ	4.6 K	4083 Ks	0.8 m^2/s	338 m^2	11 s	20 s	72 s	83 s	166 s	116 s
Relative repeatability std s_r / m	18.4 %	13.5 %	8.1 %	4.0 %	18.8 %	13 %	24.9 %	27.6 %	14.5 %	13.5 %	18.0 %	11.7 %
Relative reproducibility std s_R / m	20.1 %	15.6 %	11.6 %	10.3 %	24.2 %	23 %	33.8 %	42.4 %	21.4 %	15.5 %	20.6 %	23.7 %
For the confidence level of 95%												
Repeatability limit r	12.4 kW	4.8 MJ	9.0 K	4474 Ks	1.7 m^2/s	536 m^2	24 s	37 s	138 s	205 s	411 s	162 s
Reproducibility limit R	13.6 kW	5.6 MJ	13.0 K	11549 Ks	2.2 m^2/s	957 m^2	32 s	56 s	203 s	234 s	470 s	328 s
Relative repeatability limit r / m	52.0 %	38.1 %	22.8 %	11.3 %	53.1 %	36.1 %	70.4 %	78.1 %	41.0 %	38.3 %	51.0 %	33.2 %
Relative reproducibility limit R / m	56.9 %	44.2 %	32.9 %	29.2 %	68.4 %	64.4 %	95.7 %	120 %	60.4 %	43.7 %	58.3 %	67.0 %

RHR : **LAB02 STRAGGLER** according to Cochran's test for within laboratory variance.
THR : **LAB02 STRAGGLER** according to Grubb's test for extreme data between labs.
t_{ign} **(vis.):** **LAB16** and **LAB03 OUTLIERS** according to Grubb's test for two extreme data values between labs.

PRODUCT M03: PR Extruded Polystyrene Board

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_y edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	12	12	12
Laboratories with no erroneous data	11	11	11	11	10	10	12	11	12	9	9	11
Outliers detected in the stat. tests	0	0	0	1	0	0	1	0	1	0	0	0
Laboratories used in the stat. anal.	11	11	11	10	10	10	11	11	11	9	9	11
Level estimate m	211 kW	58.9 MJ	197.3 K	90263 Ks	5.0 m^2/s	2669 m^2	14 s	9 s	36 s	408 s	463 s	366 s
Repeatability std s_r	30.1 kW	11.6 MJ	28.5 K	12099 Ks	0.9 m^2/s	558 m^2	4 s	2 s	13 s	30 s	45 s	12 s
Reproducibility std s_R	74.2 kW	13.9 MJ	57.3 K	13384 Ks	1.3 m^2/s	1108 m^2	7 s	8 s	29 s	41 s	53 s	36 s
Relative repeatability std s_r / m	14.3 %	19.6 %	14.4 %	13.4 %	19.0 %	21 %	30.8 %	21.0 %	37.3 %	7.4 %	9.8 %	3.2 %
Relative reproducibility std s_R / m	35.1 %	23.6 %	29.0 %	14.8 %	27.1 %	41 %	48.2 %	89.9 %	80.2 %	10.0 %	11.5 %	9.9 %
For the confidence level of 95%												
Repeatability limit r	85.2 kW	32.7 MJ	80.6 K	34222 Ks	2.7 m^2/s	1579 m^2	12 s	5 s	38 s	86 s	128 s	33 s
Reproducibility limit R	210 kW	39.3 MJ	162.0 K	37855 Ks	3.8 m^2/s	3133 m^2	19 s	22 s	81 s	115 s	151 s	102 s
Relative repeatability limit r / m	40.3 %	55.5 %	40.8 %	37.5 %	53.7 %	59.2 %	87.0 %	59.5 %	105.4 %	21.0 %	27.7 %	9.1 %
Relative reproducibility limit R / m	99.4 %	66.7 %	82.1 %	41.9 %	76.5 %	117.4 %	136.4 %	254.4 %	226.7 %	28.2 %	32.5 %	27.9 %

RHR : **LAB14 STRAGGLER** according to Cochran´s test for within laboratory variance.
THR : **LAB14 STRAGGLER** according to Cochran´s test for within laboratory variance.
cum. ΔT : **LAB14 STRAGGLER** according to Cochran´s test for within laboratory variance.
TSP : **LAB03 and LAB07 STRAGGLERS** according to Grubb´s test for two extreme data values between labs.
t_{ign} (vis.) : **LAB06 OUTLIER** according to Cochran´s test for within laboratory variance and according to Grubb´s test for extreme data between labs.
t_{ign} (5 kW) : **LAB16 and LAB01 STRAGGLERS** according to Grubb´s test for extreme data between labs.
t_{ign} (3 K) : **LAB06 OUTLIER** according to Cochran´s test for within laboratory variance.
t_{x1} (350 mm) : **LAB05 STRAGGLER** according to Cochran´s test for within laboratory variance.
t_y (edge) : **LAB12 STRAGGLER** according to Cochran´s test for within laboratory variance.

PRODUCT M04: PUR Foam Panel with Alu Foil Faces

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	12	–	12
Laboratories with no erroneous data	10	10	12	11	10	9	12	10	12	12	–	12
Outliers detected in the stat. tests	1	1	0	1	2	1	1	1	0	0	–	1
Laboratories used in the stat. anal.	9	9	12	10	8	8	11	9	12	12	–	11
Level estimate m	169.2 kW	34.0 MJ	190.5 K	68662 Ks	2.46 m^2/s	990 m^2	25.0 s	17.5 s	25.1 s	439.3 s	–	331.2 s
Repeatability std s_r	16.1 kW	1.9 MJ	15.0 K	1426 Ks	0.21 m^2/s	149 m^2	6.6 s	2.2 s	2.6 s	36.0 s	–	5.2 s
Reproducibility std s_R	16.1 kW	2.3 MJ	35.4 K	8717 Ks	0.47 m^2/s	639 m^2	9.9 s	8.7 s	4.8 s	43.0 s	–	7.0 s
Relative repeatability std s_r / m	9.5 %	5.7 %	7.9 %	2.1 %	8.5 %	15.0 %	26.5 %	12.8 %	10.4 %	8.2 %	–	1.6 %
Relative reproducibility std s_R / m	9.5 %	6.8 %	18.6 %	12.7 %	18.9 %	64.6 %	39.7 %	49.9 %	19.1 %	9.8 %	–	2.1 %
For the confidence level of 95 %												
Repeatability limit r	45.5 kW	5.5 MJ	42.3 K	4034 Ks	0.59 m^2/s	420 m^2	18.7 s	6.3 s	7.4 s	101.8 s	–	14.8 s
Reproducibility limit R	45.5 kW	6.6 MJ	100.1 K	24655 Ks	1.32 m^2/s	1808 m^2	28.0 s	24.7 s	13.6 s	121.6 s	–	19.9 s
Relative repeatability limit r / m	26.9 %	16.2 %	22.2 %	5.9 %	24.0 %	42.4 %	74.9 %	36.1 %	29.4 %	23.2 %	–	4.5 %
Relative reproducibility limit R / m	26.9 %	19.3 %	52.6 %	35.9 %	53.4 %	182.6 %	112.3 %	141.1 %	54.1 %	27.7 %	–	6.0 %

cum. ΔT : **LAB01 OUTLIER** according to Cochran´s test for within laboratory variance.
RHR : **I AB03 OUTLIER** according to Grubb´s test for extreme data values between labs.
THR : **LAB03 OUTLIER** according to Grubb´s test for extreme data values between labs.
RSP : **LAB10 OUTLIER** according to Cochran´s test for within laboratory variance, and **LAB18 OUTLIER** according to Repeated Cochran´s test for within laboratory variance
TSP : **LAB18 OUTLIER** according to Cochran´s test for within laboratory variance, **LAB16 STRAGGLER** according to Repeated Cochran´s test for within laboratory variance, and **LAB07** and **LAB18 STRAGGLERS** according to Grubb´s test for two extreme data values between labs.
t_{ign} (visual) : **LAB06 OUTLIER** according to Cochran´s test for within laboratory variance and also **OUTLIER** according to Grubb´s test for extreme data values between labs.
t_{ign} (5 kW) : **LAB03 OUTLIER** according to Cochran´s test for within laboratory variance.
t_{x1} (250 mm) : **LAB12 STRAGGLER** according to Cochran´s test for within laboratory variance.
t_v (edge) : **LAB18 OUTLIER** according to Cochran´s test for within laboratory variance and also **STRAGGLER** according to Grubb´s test for extreme data values between labs.

PRODUCT M05: Mass Timber (Spruce), Varnished

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	12	12	12
Laboratories with no erroneous data	10	10	12	11	10	9	12	10	12	12	12	12
Outliers detected in the stat. tests	0	0	0	0	0	0	0	0	0	2	1	0
Laboratories used in the stat. anal.	10	10	12	11	10	9	12	10	12	10	11	12
Level estimate m	60.7 kW	35.3 MJ	87.2 K	69359 Ks	0.337 m^2/s	221.1 m^2	22.2 s	18.2 s	28.8 s	443.9 s	980.9 s	340.4 s
Repeatability std s_r	10.6 kW	2.7 MJ	12.9 K	3836 Ks	0.095 m^2/s	64.7 m^2	4.7 s	4.1 s	2.3 s	41.7 s	175.8 s	7.6 s
Reproducibility std s_R	14.4 kW	4.6 MJ	15.5 K	7909 Ks	0.211 m^2/s	158.5 m^2	6.1 s	9.0 s	2.6 s	54.4 s	175.8 s	12.5 s
Relative repeatability std s_r / m	17.5 %	7.6 %	14.8 %	5.5 %	28.2 %	29.3 %	21.3 %	22.4 %	7.8 %	9.4 %	17.9 %	2.2 %
Relative reproducibility std s_R / m	23.8 %	13.0 %	17.8 %	11.4 %	62.6 %	71.7 %	27.3 %	49.6 %	9.2 %	12.3 %	17.9 %	3.7 %
For the confidence level of 95%												
Repeatability limit r	30.1 kW	7.5 MJ	36.6 K	10850 Ks	0.269 m^2/s	182.9 m^2	13.4 s	11.5 s	6.4 s	118.0 s	497.1 s	21.6 s
Reproducibility limit R	40.8 kW	13.0 MJ	43.8 K	22370 Ks	0.598 m^2/s	448.4 m^2	17.1 s	25.5 s	7.5 s	154.0 s	497.1 s	35.3 s
Relative repeatability limit r / m	49.6 %	21.4 %	42.0 %	15.6 %	79.9 %	82.7 %	60.3 %	63.2 %	22.1 %	26.6 %	50.7 %	6.4 %
Relative reproducibility limit R / m	67.2 %	36.8 %	50.3 %	32.3 %	177.1 %	202.8 %	77.2 %	140.2 %	25.9 %	34.7 %	50.7 %	10.4 %

t_{ign} (5 kW) : **LAB03 STRAGGLER** according to Cochran's test for within laboratory variance.
t_{ign} (3 K) : **LAB14 STRAGGLER** according to Cochran's test for within laboratory variance.
t_{x1} (250 mm) : **LAB02 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB14 OUTLIER** according to Grubb's test for extreme data between labs.
t_{x2} (350 mm) : **LAB16 OUTLIER** according to Grubb's test for extreme data between labs.

PRODUCT M06: FR Chip Board

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	–	–	12
Laboratories with no erroneous data	10	10	12	11	11	10	3	10	12	–	–	2
Outliers detected in the stat. tests	0	0	0	0	1	1	0	1	0	–	–	0
Laboratories used in the stat. anal.	10	10	12	11	10	9	3	9	12	–	–	2
Level estimate m	9.0 kW	7.5 MJ	36.6 K	38987 Ks	0.337 m^2/s	312.1 m^2	167 s	93.0 s	505.5 s	–	–	735.0 s
Repeatability std s_r	1.2 kW	0.8 MJ	1.1 K	1104 Ks	0.039 m^2/s	30.5 m^2	115 s	26.8 s	77.6 s	–	–	161.9 s
Reproducibility std s_R	2.4 kW	2.1 MJ	3.7 K	4058 Ks	0.158 m^2/s	156.4 m^2	157 s	54.0 s	234.1 s	–	–	217 s
Relative repeatability std s_r / m	13.2 %	10.6 %	3.0 %	2.8 %	11.5 %	9.8 %	68.9 %	28.8 %	15.3 %	–	–	22.0 %
Relative reproducibility std s_R / m	26.1 %	27.6 %	10.1 %	10.4 %	47.0 %	50.1 %	93.8 %	58.1 %	46.3 %	–	–	29.5 %
For the confidence level of 95%										–	–	
Repeatability limit r	3.4 kW	2.3 MJ	3.1 K	3122 Ks	0.110 m^2/s	86.2 m^2	326 s	75.9 s	219.4 s	–	–	458.0 s
Reproducibility limit R	6.7 kW	5.9 MJ	10.4 K	11477 Ks	0.448 m^2/s	442.3 m^2	444 s	152.6 s	662.3 s	–	–	613.7 s
Relative repeatability limit r / m	37.4 %	30.1 %	8.3 %	8 %	32.5 %	27.6 %	195.0 %	81.5 %	43.4 %	–	–	62.3 %
Relative reproducibility limit R / m	73.7 %	78.1 %	28.4 %	29.4 %	132.8 %	141.7 %	265.2 %	164 %	131 %	–	–	83.5 %

RSP : **LAB10 OUTLIER** according to Cochran's test for within laboratory variance .
TSP : **LAB03 OUTLIER** according to Cochran's test for within laboratory variance .
t_{ign} (5 kW) : **LAB01 OUTLIER** according to Cochran's test for within laboratory variance .

PRODUCT M07: FR PC Panel, 3-Layered

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	–	–	12
Laboratories with no erroneous data	10	10	11	10	10	9	11	10	11	–	–	6
Outliers detected in the stat. tests	0	0	0	0	1	2	0	0	1	–	–	1
Laboratories used in the stat. anal.	10	10	11	10	9	7	11	10	10	–	–	5
Level estimate m	168.0 kW	25.3 MJ	143.0 K	57809 Ks	5.0 m²/s	698 m²	51.0 s	91.9 s	173.5 s	–	–	450 s
Repeatability std s_r	56.7 kW	4.5 MJ	34.3 K	7081 Ks	1.4 m²/s	175 m²	10.0 s	31.0 s	58.1 s	–	–	20 s
Reproducibility std s_R	146.4 kW	14.7 MJ	97.6 K	18890 Ks	3.5 m²/s	394 m²	12.0 s	64.1 s	96.1 s	–	–	20 s
Relative repeatability std s_r / m	33.7 %	17.7 %	24.0 %	12.2 %	27.3 %	25.1 %	19.1 %	33.7 %	33.5 %	–	–	4.5 %
Relative reproducibility std s_R / m	87.2 %	58.3 %	68.3 %	32.7 %	70.9 %	56.4 %	24.2 %	69.8 %	55.4 %	–	–	4.5 %
For the confidence level of 95 %												
Repeatability limit r	160.3 kW	12.6 MJ	97.1 K	20028 Ks	3.8 m²/s	496 m²	27.0 s	87.7 s	164.3 s	–	–	58 s
Reproducibility limit R	414.1 kW	41.7 MJ	276.2 K	53430 Ks	10.0 m²/s	1114 m²	35.0 s	181.4 s	271.7 s	–	–	58 s
Relative repeatability limit r / m	95.4 %	49.9 %	67.9 %	34.6 %	77.2 %	71.0 %	54.1 %	95.4 %	94.7 %	–	–	12.8 %
Relative reproducibility limit R / m	246.5 %	164.8 %	193.1 %	92.4 %	200.5 %	159.5 %	68.3 %	197.4 %	156.6 %	–	–	12.8 %

cum. ΔT : **LAB12 STRAGGLER** according to Cochran's test for within laboratory variance .
RSP : **LAB10 OUTLIER** according to Cochran's test for within laboratory variance .
TSP : **LAB01** and **LAB07 OUTLIERS** according to Grubb's test for two extreme data values between labs , **LAB01** also **STRAGGLER** according to Cochran's test for within laboratory variance .
t_{ign} (5 kW) : **LAB02 STRAGGLER** according to Cochran's test for within laboratory variance , and **LAB06** and **LAB17 STRAGGLERS** according to Grubb's test for two extreme data values between labs.
t_{ign} (3 K) : **LAB03 OUTLIER** according to Cochran's test for within laboratory variance , and according to Grubb's test for extreme data values between labs.
t_v (edge) : **LAB03 OUTLIER** according to Grubb's test for extreme data values between labs.

PRODUCT M08: Painted Paper-Faced Gypsum Plasterboard

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_y edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	–	–	–
Laboratories with no erroneous data	10	10	12	11	11	10	7	10	6	–	–	–
Outliers detected in the stat. tests	0	0	0	0	1	1	0	1	0	–	–	–
Laboratories used in the stat. anal.	10	10	12	11	10	9	7	9	6	–	–	–
Level estimate *m*	5.7 kW	2.7 MJ	31.5 K	35167 Ks	0.133 m^2/s	99.2 m^2	71.6 s	48.2 s	895 s	–	–	–
Repeatability std s_r	1.1 kW	1.1 MJ	0.58 K	690 Ks	0.015 m^2/s	14.4 m^2	19.4 s	4.9 s	114 s	–	–	–
Reproducibility std s_R	1.1 kW	1.5 MJ	2.6 K	3026 Ks	0.086 m^2/s	41.9 m^2	28.1 s	9.2 s	298 s	–	–	–
Relative repeatability std s_r / m	18.4 %	41.2 %	1.8 %	2.0 %	11.6 %	14.5 %	27.0 %	10.1 %	12.7 %	–	–	–
Relative reproducibility std s_R / m	19.2 %	56.0 %	8.1 %	8.6 %	64.7 %	42.3 %	39.2 %	19 %	33.3 %	–	–	–
For the confidence level of 95%												
Repeatability limit *r*	3.0 kW	3.1 MJ	1.6 K	1953 Ks	0.044 m^2/s	40.8 m^2	54.7 s	13.8 s	323 s	–	–	–
Reproducibility limit *R*	3.1 kW	4.3 MJ	7.2 K	8558 Ks	0.244 m^2/s	118.6 m^2	79.4 s	25.9 s	842 s	–	–	–
Relative repeatability limit r / m	51.9 %	116.5 %	5.2 %	5.6 %	32.7 %	41.1 %	76.5 %	28.6 %	36 %	–	–	–
Relative reproducibility limit R / m	54.4 %	158.5 %	22.9 %	24.3 %	182.9 %	119.5 %	110.9 %	53.7 %	94.1 %	–	–	–

RSP : **LAB16 OUTLIER** according to Cochran´s test for within laboratory variance .
TSP : **LAB01 OUTLIER** according to Grubb´s test for extreme data values between labs .
t_{ign} (5 kW) : **LAB18 OUTLIER** according to Cochran´s test for within laboratory variance.

PRODUCT M09: Paper Wallcovering on Gypsum Plasterboard

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	–	–	12
Laboratories with no erroneous data	10	10	12	11	11	10	11	10	12	–	–	3
Outliers detected in the stat. tests	0	0	0	0	0	1	0	1	0	–	–	0
Laboratories used in the stat. anal.	10	10	12	11	11	9	11	9	12	–	–	3
Level estimate m	13.5 kW	3.4 kW	34.7 K	35736 K	0.135 m^2/s	104.0 m^2	37.7 s	31.7 s	46.5 s	–	–	338.6 s
Repeatability std s_r	1.3 kW	0.67 kW	1.2 K	560 K	0.018 m^2/s	16.5 m^2	7.4 s	1.8 s	4.5 s	–	–	5.6 s
Reproducibility std s_R	1.3 kW	1.0 kW	3.1 K	3151 K	0.069 m^2/s	36.8 m^2	10.2 s	8.6 s	7.2 s	–	–	19.2 s
Relative repeatability std s_r / m	9.4 %	19.6 %	3.4 %	1.6 %	13.2 %	15.8 %	19.7 %	5.8 %	9.8%	–	–	1.6 %
Relative reproducibility std s_R / m	9.8 %	30.5 %	8.9 %	8.8 %	51.1 %	35.4 %	27.1 %	27.2 %	15.4%	–	–	5.7 %
For the confidence level of 95%												
Repeatability limit r	3.6 kW	1.9 kW	3.4 K	1585 K	0.050 m^2/s	46.6 m^2	21.0 s	5.2 s	12.8 s	–	–	15.8 s
Reproducibility limit R	3.8 kW	2.9 kW	8.7 K	8912 K	0.196 m^2/s	104.1 m^2	28.9 s	24.4 s	20.3 s	–	–	54.4 s
Relative repeatability limit r / m	26.5 %	55.5 %	9.7 %	4.4 %	37.2 %	44.8 %	55.7 %	16.4 %	27.6%	–	–	4.7 %
Relative reproducibility limit R / m	27.8 %	86.2 %	25.1 %	24.9 %	144.6 %	100.2 %	76.6 %	77.0 %	43.7%	–	–	16.1 %

THR: **LAB18 STRAGGLER** according to Grubb's test for extreme data values between labs.
RSP : **LAB01** and **LAB10 STRAGGLERS** according to Grubb's test for two extreme data values between labs
TSP : **LAB01 OUTLIER** according to Grubb's test for extreme data values between labs, and **LAB14 STRAGGLER** according to Grubb's test for extreme data values between labs.
t_{ign} (5 kW) : **LAB03 OUTLIER** according to Cochran's test for within laboratory variance.

PRODUCT M10: PVC Wallcarpet on Gypsum Plasterboard

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	12	12	12	12	12	12	12	12	12	12	–	12
Laboratories with no erroneous data	10	10	12	11	10	9	12	10	12	3	–	11
Outliers detected in the stat. tests	1	0	0	0	0	0	1	0	0	0	–	2
Laboratories used in the stat. anal.	9	10	12	11	10	9	11	10	12	3	–	9
Level estimate m	29.3 kW	8.7 kW	48 K	40022 Ks	0.78 m^2/s	291.6 m^2	20.0 s	20.9 s	39.2 s	530.8 s	–	344.5 s
Repeatability std s_r	2.7 kW	0.61 kW	3.7 K	728.0 Ks	0.06 m^2/s	38.2 m^2	3.2 s	2.1 s	3.3 s	–	–	4.3 s
Reproducibility std s_R	5.6 kW	1.5 kW	7.5 K	4438 Ks	0.22 m^2/s	100.2 m^2	5.3 s	6.3 s	5.9 s	–	–	12.3 s
Relative repeatability std s_r / m	9.4 %	7.0 %	7.7 %	1.8 %	8 %	13.1 %	16.1 %	9.8 %	8.5 %	–	–	1.3 %
Relative reproducibility std s_R / m	18.9 %	17.3 %	15.7 %	11.1 %	28 %	34.4 %	26.5 %	30.3 %	14.9 %	–	–	3.6 %
For the confidence level of 95%												
Repeatability limit r	7.8 kW	1.7 kW	10.4 K	2059 Ks	0.18 m^2/s	107.9 m^2	9.1 s	5.8 s	9.4 s	–	–	12.3 s
Reproducibility limit R	15.7 kW	4.3 kW	21.3 K	12554 Ks	0.62 m^2/s	283.5 m^2	15 s	17.9 s	16.6 s	–	–	34.7 s
Relative repeatability limit r / m	26.5 %	19.7 %	21.7 %	5.1 %	22.6 %	37.0 %	45.6 %	27.7 %	24.1 %	–	–	3.6 %
Relative reproducibility limit R / m	53.5 %	49.0 %	44.3 %	31.4 %	79.3 %	97.2 %	74.9 %	85.7 %	42.2 %	–	–	10.1 %

ΔT : **LAB01** and **LAB14 STRAGGLERS** according to Grubb's test for two extreme data values between labs..
RHR: **LAB02 OUTLIER** according to Cochran's test for within laboratory variance.
t_{ign} (visual) : **LAB05 OUTLIER** according to Cochran's test for within laboratory variance, and according to Grubb's test for extreme data values between labs.
t_{ign} (3 K) : **LAB02 STRAGGLER** according to Cochran's test for within laboratory variance.
t_v (edge) : **LAB17 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB10 OUTLIER** according to repeated Cochran's test for within laboratory variance.

PRODUCT M11: Plastic-Faced Steel Sheet on Mineral Wool

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	14	–	14
Laboratories with no erroneous data	14	14	14	14	12	12	14	14	11	7	–	5
Outliers detected in the stat. tests	1	0	0	0	1	1	0	1	0	1	–	0
Laboratories used in the stat. anal.	13	14	14	14	11	11	14	13	11	6	–	5
Level estimate m	7.4 kW	3.6 MJ	32.6 K	36160 Ks	0.507 m^2/s	282.0 m^2	27.0 s	33.8 s	705.2 s	684.6 s	–	439.0 s
Repeatability std s_r	0.98 kW	0.88 MJ	0.8 K	715 Ks	0.054 m^2/s	53.4 m^2	2.9 s	5.8 s	167.3 s	91.3 s	–	30.3 s
Reproducibility std s_R	1.2 kW	1.5 MJ	3.6 K	3989 Ks	0.150 m^2/s	146.2 m^2	3.7 s	10.2 s	288.6 s	316.7 s	–	182.2 s
Relative repeatability std s_r / m	13.3 %	24.4 %	2.4 %	2.0 %	10.6 %	18.9 %	10.8 %	17.2 %	23.7 %	13.3 %	–	6.9 %
Relative reproducibility std s_R / m	16.2 %	41.5 %	11.0 %	11.0 %	29.5 %	51.8 %	13.8 %	30.1 %	40.9 %	46.3 %	–	41.5 %
For the confidence level of 95%												
Repeatability limit r	2.8 kW	2.5 MJ	2.2 K	2023 Ks	0.152 m^2/s	151.1 m^2	8.3 s	16.4 s	473.2 s	258.2 s	–	85.8 s
Reproducibility limit R	3.4 kW	4.2 MJ	10.1 K	11282 Ks	0.423 m^2/s	413.5 m^2	10.5 s	28.7 s	816.3 s	895.9 s	–	515.4 s
Relative repeatability limit r / m	37.7 %	69.0 %	6.7 %	5.6 %	30.1 %	53.6 %	30.6 %	48.5 %	67.1 %	37.7 %	–	19.6 %
Relative reproducibility limit R / m	45.8 %	117.3 %	31.0 %	31.2 %	83.5 %	146.6 %	38.9 %	85.1 %	115.7 %	130.9 %	–	117.4 %

RHR : **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance.

THR : **LAB06 STRAGGLER** according to Cochran´s test for within laboratory variance; **LAB11** and **LAB18 STRAGGLERS** according to Grubb´s test for two extreme data values between labs

RSP : **LAB07 OUTLIER** according to Grubb´s test for extreme data values between labs, and **STRAGGLER** according to Cochran´s test for within laboratory variance.

TSP : **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance, and also according to Grubb´s test for extreme data values between labs; **LAB06** and **LAB17 STRAGGLERS** according to Repeated Cochran´s test for within laboratory variance.

t_{ign} (5kW) **LAB09 OUTLIER** according to Cochran´s test for within laboratory variance.

t_{x1} (250 mm) **LAB03 OUTLIER** according to Cochran´s test for within laboratory variance, and **LAB11 STRAGGLER** according to Grubb´s test for extreme data values between labs.

t_v (edge) **LAB12** and **LAB18 STRAGGLERS** according to Grubb´s test for two extreme data values between labs

PRODUCT M12: Mass Timber (Spruce), Unvarnished

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	14	14	14
Laboratories with no erroneous data	14	14	14	14	13	13	14	14	14	13	14	13
Outliers detected in the stat. tests	1	0	0	0	1	1	0	1	1	0	0	1
Laboratories used in the stat. anal.	13	14	14	14	12	12	14	13	13	13	14	12
Level estimate m	64.9 kW	39.2 MJ	96.3 K	73092 Ks	0.215 m^2/s	136.3 m^2	27.7 s	23.9 s	34.1 s	531.7 s	947.9 s	350.9 s
Repeatability std s_r	12.5 kW	4.1 MJ	15.0 K	3249 Ks	0.046 m^2/s	26.8 m^2	6.0 s	2.5 s	3.0 s	74.5 s	162.9 s	7.2 s
Reproducibility std s_R	16.2 kW	6.7 MJ	19.2 K	8168 Ks	0.098 m^2/s	74.0 m^2	8.2 s	8.6 s	5.4 s	88.5 s	243.3 s	24.5 s
Relative repeatability std s_r / m	19.3 %	10.4 %	15.5 %	4.4 %	21.2 %	19.7 %	21.7 %	10.4 %	8.7 %	14.0 %	17.2 %	2.1 %
Relative reproducibility std s_R / m	24.9 %	17.1 %	20.0 %	11.2 %	45.5 %	54.3 %	29.6 %	36.1 %	15.9 %	16.6 %	25.7 %	7.0 %
For the confidence level of 95%												
Repeatability limit r	35.4 kW	11.5 MJ	42.3 K	9188 Ks	0.129 m^2/s	75.8 m^2	17.0 s	7.0 s	8.4 s	210.7 s	460.6 s	20.4 s
Reproducibility limit R	45.7 kW	18.9 MJ	54.4 K	23104 Ks	0.277 m^2/s	209.2 m^2	23.2 s	24.4 s	15.3 s	250.3 s	688.1 s	69.4 s
Relative repeatability limit r / m	54.5 %	29.5 %	44.0 %	12.6 %	59.8 %	55.7 %	61.4 %	29.4 %	24.7 %	39.6 %	48.6 %	5.8 %
Relative reproducibility limit R / m	70.4 %	48.4 %	56.5 %	31.6 %	128.7 %	153.5 %	83.7 %	102.0 %	45.0 %	47.1 %	72.6 %	19.8 %

RHR : **LAB04 OUTLIER** according to Cochran´s test for within laboratory variance.
RSP : **LAB07 OUTLIER** according to Grubb´s test for extreme data values between labs, and **STRAGGLER** according to Cochran´s test for within laboratory variance.
TSP : **LAB07 OUTLIER** according to Grubb´s test for extreme data values between labs, and **STRAGGLER** according to Cochran´s test for within laboratory variance.
t_{ign} (5 kW) **LAB11 OUTLIER** according to Cochran´s test for within laboratory variance.
t_{ign} (3 K) **LAB11 OUTLIER** according to Cochran´s test for within laboratory variance.
t_{x1} (350 mm): LAB11 **STRAGGLER** according to Grubb´s test for extreme data values between labs.
t_v (edge) **LAB01 OUTLIER** according to Cochran´s test for within laboratory variance.

PRODUCT M13: Gypsum Plasterboard on Polystyrene

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{s1} 250 mm	t_{s2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	–	–	–
Laboratories with no erroneous data	12	12	13	13	12	12	6	11	6	–	–	–
Outliers detected in the stat. tests	2	2	2	0	2	2	2	1	0	–	–	–
Laboratories used in the stat. anal.	10	10	11	13	10	10	4	10	6	–	–	–
Level estimate m	5.00 kW	2.54 MJ	31.0 K	35378 Ks	0.162 m^2/s	149.6 m^2	75.8 s	56.1 s	874.9 s	–	–	–
Repeatability std s_r	0.59 kW	0.67 MJ	0.6 K	1054 Ks	0.012 m^2/s	13.5 m^2	11.2 s	6.4 s	186.3 s	–	–	–
Reproducibility std s_R	0.66 kW	1.24 MJ	3.1 K	3807 Ks	0.111 m^2/s	99.5 m^2	17.2 s	11.8 s	225.5 s	–	–	–
Relative repeatability std s_r / m	11.8 %	26.2 %	2.0 %	3.0 %	7.7 %	9.1 %	14.8 %	11.5 %	21.3 %	–	–	–
Relative reproducibility std s_R / m	13.1 %	48.7 %	9.9 %	10.8 %	68.7 %	66.5 %	22.7 %	21.1 %	25.8 %	–	–	–
For the confidence level of 95%												
Repeatability limit r	1.67 kW	1.89 MJ	1.8 K	2981 Ks	0.035 m^2/s	38.3 m^2	31.7 s	18.2 s	527.0 s	–	–	–
Reproducibility limit R	1.86 kW	3.50 MJ	8.7 K	10767 Ks	0.314 m^2/s	281.5 m^2	48.6 s	33.4 s	637.7 s	–	–	–
Relative repeatability limit r / m	33.4 %	74.2 %	5.7 %	8.4 %	21.7 %	25.6 %	41.8 %	32.4 %	60.2 %	–	–	–
Relative reproducibility limit R / m	37.2 %	137.8 %	27.9 %	30.4 %	194.2 %	188.2 %	64.2 %	59.5 %	72.9 %	–	–	–

ΔT : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance, and **OUTLIER** also according to Grubb's test for extreme data values between labs.
LAB16 OUTLIER according to Repeated Cochran's test for within laboratory variance

cum. ΔT : LAB11 **STRAGGLER** according to Cochran's test for within laboratory variance.

RHR : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance, and **OUTLIER** also according to Grubb's test for extreme data values between labs.
LAB07 OUTLIER according to Repeated Cochran's test for within laboratory variance

THR : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance, and **OUTLIER** also according to Grubb's test for extreme data values between labs.
LAB07 OUTLIER according to Repeated Cochran's test for within laboratory variance

RSP : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance, and **OUTLIER** also according to Grubb's test for extreme data values between labs.
LAB16 OUTLIER according to Repeated Cochran's test for within laboratory variance

TSP : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance, and **OUTLIER** also according to Grubb's test for extreme data values between labs.

t_{ign} (visual) **LAB07 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB07** and **LAB12 OUTLIERS** according to Grubb's test for two extreme data values between labs.

t_{ign} (5 kW) **LAB03 OUTLIER** according to Cochran's test for within laboratory variance.

PRODUCT M14: Phenolic Foam

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	–	–	14
Laboratories with no erroneous data	14	14	14	14	13	13	7	14	14	–	–	3
Outliers detected in the stat. tests	0	0	1	1	0	0	0	0	0	–	–	1
Laboratories used in the stat. anal.	14	14	13	13	13	13	7	14	14	–	–	2
Level estimate *m*	9.9 kW	9.1 MJ	38.2 K	42126 Ks	0.202 m^2/s	176.4 m^2	490 s	20.2 s	20.2 s	–	–	314.7 s
Repeatability std s_r	0.85 kW	0.68 MJ	0.93 K	866 Ks	0.023 m^2/s	18.3 m^2	124 s	4.5 s	4.5 s	–	–	2.3 s
Reproducibility std s_R	2.5 kW	1.7 MJ	3.7 K	4096 Ks	0.122 m^2/s	98.9 m2	377 s	11.1 s	11.1 s	–	–	10.1 s
Relative repeatability std s_r / m	8.6 %	7.4 %	2.4 %	2.1 %	11.5 %	10.4 %	25.2 %	22.5 %	22.5 %	–	–	0.7 %
Relative reproducibility std s_R / m	25.6 %	18.7 %	9.7 %	9.7 %	60.3 %	56.1 %	77.0 %	55.0 %	55.0 %	–	–	3.2 %
For the confidence level of 95%												
Repeatability limit *r*	2.4 kW	1.9 MJ	2.6 K	2449 Ks	0.066 m^2/s	51.7 m^2	350 s	12.8 s	12.8 s	–	–	6.5 s
Reproducibility limit *R*	7.2 kW	4.8 MJ	10.5 K	11584 Ks	0.344 m^2/s	279.9 m^2	1067 s	31.4 s	31.4 s	–	–	28.5 s
Relative repeatability limit r / m	24.4 %	21.0 %	6.9 %	5.8 %	32.6 %	29.3 %	71.3 %	63.7 %	63.7 %	–	–	2.1 %
Relative reproducibility limit R / m	72.4 %	52.8 %	27.5 %	27.5 %	170.6 %	158.6 %	217.7 %	155.6 %	155.6 %	–	–	9.1 %

ΔT : **LAB17 OUTLIER** according to Cochran´s test for within laboratory variance.
cum. ΔT : **LAB17 OUTLIER** according to Cochran´s test for within laboratory variance.
TSP : **LAB14 STRAGGLER** according to Cochran´s test for within laboratory variance.
t_v (edge): **LAB12 OUTLIER** according to Cochran´s test for within laboratory variance.

PRODUCT M15: Intumescent Coat on Particle Board

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	14	–	14
Laboratories with no erroneous data	14	14	14	14	13	13	11	14	14	2	–	7
Outliers detected in the stat. tests	0	0	0	0	2	2	0	2	2	0	–	1
Laboratories used in the stat. anal.	14	14	14	14	11	11	11	12	12	2	–	6
Level estimate m	10.5 kW	7.8 MJ	39.7 K	41043 Ks	0.174 m^2/s	172.7 m^2	397.3 s	63.9 s	411.7 s	629.5 s	–	680.3 s
Repeatability std s_r	2.9 kW	2.4 MJ	2.0 K	2149 Ks	0.012 m^2/s	14.9 m^2	104.2 s	46.4 s	81.1 s	137.1 s	–	127.5 s
Reproducibility std s_R	4.0 kW	3.0 MJ	5.3 K	5176 Ks	0.088 m^2/s	95.2 m^2	148.8 s	99.2 s	100.6 s	137.1 s	–	363.7 s
Relative repeatability std s_r / m	27.3 %	30.2 %	5.1 %	5.2 %	6.6 %	8.7 %	26.2 %	72.6 %	19.7 %	21.8 %	–	18.7 %
Relative reproducibility std s_R / m	37.5 %	38.6 %	13.3 %	12.6 %	50.8 %	55.1 %	37.4 %	155.3 %	24.4 %	21.8 %	–	53.5 %
For the confidence level of 95%												
Repeatability limit r	8.1 kW	6.7 MJ	5.8 K	6078 Ks	0.033 m^2/s	42.3 m^2	294.9 s	131.2 s	229.5 s	387.7 s	–	360.6 s
Reproducibility limit R	11.2 kW	8.5 MJ	15.0 K	14641 Ks	0.250 m^2/s	269.2 m^2	420.8 s	280.7 s	284.5 s	387.7 s	–	1028.6 s
Relative repeatability limit r / m	77.3 %	85.4 %	14.5 %	14.8 %	18.7 %	24.5 %	74.2 %	205.3 %	55.8 %	61.6 %	–	53.0 %
Relative reproducibility limit R / m	106.1 %	109.3 %	37.7 %	35.7 %	143.7 %	155.9 %	105.9 %	439.3 %	69.1 %	61.6 %	–	151.2 %

max. RHR : **LAB11** and **LAB18 STRAGGLERS** according to Grubb´s test for two extreme data values between labs.

max. RSP : **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance and **OUTLIER** also according to Grubb´s test for extreme data values between labs;
LAB11 OUTLIER according to Repeated Cochran´s test for within laboratory variance

TSP : **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance , and **LAB11 OUTLIER** according to Repeated Cochran´s test for within laboratory variance;
LAB07 and **LAB11** also **STRAGGLERS** according to Grubb´s test for two extreme data values between labs.

t_{ign} (5 kW) : **LAB02 OUTLIER** according to Cochran´s test for within laboratory variance , and **LAB17 OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

t_{ign} (3 K) : **LAB02** and **LAB07 OUTLIERS** according to Grubb´s test for two extreme data values between labs.

t_v (edge) **LAB06 OUTLIER** according to Cochran´s test for within laboratory variance , and **LAB10 OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

PRODUCT M16: Melamine-Faced MDF Board

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	14	–	14
Laboratories with no erroneous data	14	14	14	14	13	13	14	14	14	14	–	13
Outliers detected in the stat. tests	0	1	0	0	2	2	1	1	0	1	–	1
Laboratories used in the stat. anal.	14	13	14	14	11	11	13	13	14	13	–	12
Level estimate *m*	78.2 kW	45.0 MJ	111.2 K	86905 Ks	0.212 m^2/s	154.6 m^2	39.5 s	39.3 s	46.8 s	541.2 s	–	379.9 s
Repeatability std s_r	10.5 kW	3.5 MJ	11.8 K	4532 Ks	0.053 m^2/s	40.5 m^2	6.9 s	4.8 s	4.9 s	47.1 s	–	7.2 s
Reproducibility std s_R	12.6 kW	4.6 MJ	17.4 K	12034 Ks	0.135 m^2/s	103.9 m^2	11.9 s	12.9 s	7.2 s	170.0 s	–	42.1 s
Relative repeatability std s_r / m	13.4 %	7.8 %	10.6 %	5.2 %	25.0 %	26.2 %	17.4 %	12.1 %	10.4 %	8.7 %	–	1.9 %
Relative reproducibility std s_R / m	16.1 %	10.3 %	15.6 %	13.8 %	63.6 %	67.2 %	30.3 %	32.9 %	15.3 %	31.4 %	–	11.1 %
For the confidence level of 95%												
Repeatability limit *r*	29.7 kW	9.9 MJ	33.2 K	12820 Ks	0.150m^2/s	114.4 m^2	19.4 s	13.5 s	13.8 s	133.2 s	–	20.4 s
Reproducibility limit *R*	35.6 kW	13.0 MJ	49.2 K	34036 Ks	0.381m^2/s	293.8 m^2	33.8 s	36.5 s	20.3 s	480.9 s	–	119.0 s
Relative repeatability limit *r / m*	37.9 %	21.9 %	29.9 %	14.8 %	70.7 %	74.0 %	49.3 %	34.4 %	29.4 %	24.6 %	–	5.4 %
Relative reproducibility limit *R / m*	45.6 %	29.0 %	44.2 %	39.2 %	179.9 %	190.0 %	85.6 %	93.0 %	43.4 %	88.8 %	–	31.3 %

THR : **LAB11** according to Grubb´s test for extreme data values between labs.

RSP : **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance and **OUTLIER** also according to Grubb´s test for extreme data values between labs;
LAB16 OUTLIER according to Repeated Cochran´s test for within laboratory variance.

TSP : **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance and **OUTLIER** also according to Grubb´s test for extreme data values between labs;
LAB16 OUTLIER according to Repeated Cochran´s test for within laboratory variance.

t_{ign} (visual) **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance , and **LAB03 STRAGGLER** according to Repeated Cochran´s test for within laboratory variance.

t_{ign} (5 kW) **LAB18 OUTLIER** according to Cochran´s test for within laboratory variance , and **LAB03 OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

t_{x1} (250 mm) **LAB04 OUTLIER** according to Cochran´s test for within laboratory variance , and **LAB14 OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

t_v (edge) **LAB18 OUTLIER** according to Cochran´s test for within laboratory variance.

PRODUCT M17: PVC Water Pipe

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	14	–	14
Laboratories with no erroneous data	12	12	12	12	12	12	12	12	12	6	–	8
Outliers detected in the stat. tests	0	0	0	0	1	1	0	0	0	1	–	1
Laboratories used in the stat. anal.	12	12	12	12	11	11	12	12	12	5	–	7
Level estimate *m*	35.2 kW	21.1 MJ	50.5 K	46635 Ks	5.21 m^2/s	2735 m^2	28.4 s	97.1 s	258.0 s	569.1 s	–	481.5 s
Repeatability std s_r	5.6 kW	2.3 MJ	4.0 K	1932 Ks	0.57 m^2/s	220 m^2	5.0 s	22.7 s	25.8 s	33.8 s	–	22.2 s
Reproducibility std s_R	6.9 kW	4.7 MJ	7.6 K	6294 Ks	1.34 m^2/s	760 m^2	7.8 s	29.9 s	41.6 s	67.9 s	–	106.6 s
Relative repeatability std s_r / m	16.1 %	11.0 %	7.9 %	4.1 %	10.8 %	8.1 %	17.8 %	23.3 %	10.0 %	5.9 %	–	4.6 %
Relative reproducibility std s_R / m	19.5 %	22.3 %	15.1 %	13.5 %	25.8 %	27.8 %	27.4 %	30.8 %	16.1 %	11.9 %	–	22.1 %
For the confidence level of 95%												
Repeatability limit *r*	16.0 kW	6.6 MJ	11.3 K	5465 Ks	1.60 m^2/s	624 m^2	14.3 s	64.1 s	72.9 s	95.6 s	–	62.8 s
Reproducibility limit *R*	19.4 kW	13.3 MJ	21.5 K	17803 Ks	3.80 m^2/s	2149 m^2	22.1 s	84.7 s	117.8 s	192.1 s	–	301.4 s
Relative repeatability limit r / m	45.4 %	31.2 %	22.3 %	11.7 %	30.7 %	22.8 %	50.2 %	66.0 %	28.3 %	16.8 %	–	13.1 %
Relative reproducibility limit R / m	55.2 %	63.2 %	42.7 %	38.2 %	72.9 %	78.6 %	77.5 %	87.2 %	45.6 %	33.7 %	–	62.6 %

RHR : **LAB06 STRAGGLER** according to Cochran's test for within laboratory variance.
THR : **LAB12 STRAGGLER** according to Cochran's test for within laboratory variance.
RSP : **LAB06 OUTLIER** according to Cochran's test for within laboratory variance.
TSP : **LAB16 OUTLIER** according to Cochran's test for within laboratory variance.
t_{ign} (5 kW) : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance , and **LAB02 OUTLIER** according to Repeated Cochran's test for within laboratory variance.
t_{ign} (3 K) : **LAB02 OUTLIER** according to Grubb's test for extreme data values between labs;.
t_{x1} (250 mm) : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance , and **LAB07** and **LAB11 STRAGGLERS** according to Grubb's test for two extreme data values between labs.
t_v (edge) : **LAB18 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB02 STRAGGLER**according to Repeated Cochran's te for within laboratory variance.

PRODUCT M18: Plastic Electric Cables

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	14	–	14
Laboratories with no erroneous data	11	11	11	11	9	9	11	11	11	3	–	10
Outliers detected in the stat. tests	0	0	0	0	0	0	0	0	1	0	–	2
Laboratories used in the stat. anal.	11	11	11	11	9	9	11	11	10	3	–	8
Level estimate m	120.0 kW	110.1 MJ	152.1 K	137540 Ks	2.0 m^2/s	1328 m^2	19.7 s	38.5 s	97.2 s	420.4 s	–	401.1 s
Repeatability std s_r	7.6 kW	5.8 MJ	10.6 K	9434 Ks	0.4 m^2/s	344.9 m^2	3.2 s	5.8 s	7.6 s	35.9 s	–	7.0 s
Reproducibility std s_R	15.7 kW	13.7 MJ	26.0 K	25637 Ks	0.8 m^2/s	658.1 m^2	5.7 s	12.6 s	22.4 s	161.9 s	–	33.2 s
Relative repeatability std s_r / m	6.3%	5.2%	7.0%	6.9%	18.3%	26.0%	16.3 %	15.0 %	7.8 %	8.5 %	–	1.7 %
Relative reproducibility std s_R / m	13.0 %	12.4 %	17.1 %	18.6 %	37.9 %	49.5 %	28.7 %	32.8 %	23.0 %	38.5 %	–	8.3 %
For the confidence level of 95 %												
Repeatability limit r	21.4 kW	16.3 MJ	29.9 K	26684 Ks	1.1 m^2/s	975.5 m^2	9.1 s	16.4 s	21.4 s	101.5 s	–	19.8 s
Reproducibility limit R	44.3 kW	38.7 MJ	73.5 K	72513 Ks	2.2 m^2/s	1861 m^2	16.0 s	35.7 s	63.3 s	458.0 s	–	94.0 s
Relative repeatability limit r / m	17.8 %	14.8 %	19.7 %	19.4 %	51.7 %	73.4 %	46.1 %	42.5 %	22.0 %	24.1 %	–	4.9 %
Relative reproducibility limit R / m	36.9 %	35.2 %	48.3 %	52.7 %	107.3 %	140.1 %	81.3 %	92.7 %	65.1 %	108.9 %	–	23.4 %

RSP : **LAB01 STRAGGLER** according to Cochran´s test for within laboratory variance.
t_{ign} (3 K) : **LAB01 OUTLIER** according to Cochran´s test for within laboratory variance.
t_v (edge) : **LAB04 OUTLIER** according to Cochran´s test for within laboratory variance, and **LAB02 OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

PRODUCT M19: Unfaced Rockwool

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_y edge
Laboratories reporting results	14	14	14	14	14	14	–	14	14	–	–	–
Laboratories with no erroneous data	13	13	14	14	13	13	–	8	10	–	–	–
Outliers detected in the stat. tests	0	0	0	0	1	0	–	0	0	–	–	–
Laboratories used in the stat. anal.	13	13	14	14	12	13	–	8	10	–	–	–
Level estimate m	3.8 kW	2.9 MJ	33.4 K	37432 Ks	0.129 m^2/s	144.1 m^2	–	279.3 s	622.4 s	–	–	–
Repeatability std s_r	0.93 kW	1.0 MJ	0.54 K	587 Ks	0.019 m^2/s	22.7 m^2	–	343.8 s	88.0 s	–	–	–
Reproducibility std s_R	2.1 kW	1.7 MJ	3.3 K	3720 Ks	0.074 m^2/s	100.7 m^2	–	343.8 s	256.1 s	–	–	–
Relative repeatability std s_r / m	24.4 %	33.0 %	1.6 %	1.6 %	14.6 %	15.8 %	–	123.1 %	14.1 %	–	–	–
Relative reproducibility std s_R / m	53.7 %	59.9 %	10.0 %	9.9 %	57.0 %	69.9 %	–	123.1 %	41.1 %	–	–	–
For the confidence level of 95 %												
Repeatability limit r	2.6 kW	2.7 MJ	1.5 K	1660 Ks	0.054 m^2/s	64.3 m^2	–	972.4 s	248.8 s	–	–	–
Reproducibility limit R	5.8 kW	4.9 MJ	9.4 K	10521 Ks	0.209 m^2/s	284.7 m^2	–	972.4 s	724.3 s	–	–	–
Relative repeatability limit r / m	69.0 %	93.3 %	4.6 %	4.4 %	41.4 %	44.6 %	–	348.2 %	40.0 %	–	–	–
Relative reproducibility limit R / m	152.0 %	169.4 %	28.3 %	28.1 %	161.3 %	197.6 %	–	348.2 %	116.4 %	–	–	–

RHR : **LAB11 STRAGGLER** according to Cochran´s test for within laboratory variance, and **STRAGGLER** also according to Grubb´s test for extreme data values between labs; **LAB07** and **LAB11 STRAGGLERS** also according to Grubb´s test for two extreme data values between labs.

RSP : **LAB01 OUTLIER** according to Grubb´s test for extreme data values between labs, **and STRAGGLER** according to Cochran´s test for within laboratory variance

TSP : **LAB01 STRAGGLER** according to Cochran´s test for within laboratory variance, and **STRAGGLER** also according to Grubb´s test for extreme data values between labs;

t_{ign} (3 K) : **LAB02 STRAGGLER** according to Cochran´s test for within laboratory variance.

PRODUCT M20: Melamine-Faced Particle Board

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	14	14	14	14	14	14	14	14	14	14		14
Laboratories with no erroneous data	13	13	13	13	12	12	13	13	13	12		12
Outliers detected in the stat. tests	0	0	0	0	2	1	1	2	2	0		1
Laboratories used in the stat. anal.	13	13	13	13	10	11	12	11	11	12		11
Level estimate m	65.2 kW	35.4 MJ	100.3 K	74443 Ks	0.240 m^2/s	221.3 m^2	47.4 s	36.5 s	54.9 s	597.0 s	s	377.4 s
Repeatability std s_r	3.9 kW	3.6 MJ	4.7 K	3647 Ks	0.038 m^2/s	34.0 m^2	4.5 s	8.9 s	3.5 s	36.4 s	s	6.5 s
Reproducibility std s_R	5.8 kW	4.9 MJ	12.8 K	8320 Ks	0.174 m^2/s	156.7 m^2	5.8 s	8.9 s	5.2 s	72.8 s	s	35.8 s
Relative repeatability std s_r / m	6.1 %	10.2 %	4.6 %	4.9 %	15.8 %	15.4 %	9.5 %	24.4 %	6.3 %	6.1 %	%	1.7 %
Relative reproducibility std s_R / m	8.8 %	13.7 %	12.7 %	11.2 %	72.4 %	70.8 %	12.1 %	24.4 %	9.5 %	12.2 %	%	9.5 %
For the confidence level of 95 %												
Repeatability limit r	11.2 kW	10.2 MJ	13.2 K	10315 Ks	0.107 m^2/s	96.2 m^2	12.8 s	25.2 s	9.8 s	102.9 s	s	18.3 s
Reproducibility limit R	16.3 kW	13.8 MJ	36.1 K	23532 Ks	0.492 m^2/s	443.1 m^2	16.3 s	25.2 s	14.7 s	205.9 s	s	101.2 s
Relative repeatability limit r / m	17.1 %	28.8 %	13.1 %	13.9 %	44.6 %	43.5 %	26.9 %	68.9 %	17.8 %	17.2 %	%	4.9 %
Relative reproducibility limit R / m	25.0 %	38.9 %	36.0 %	31.6 %	204.8 %	200.2 %	34.3 %	68.9 %	26.8 %	34.5 %	%	26.8 %

ΔT : **LAB01** and **LAB02 STRAGGLERS** also according to Grubb´s test for two extreme data values between labs;

RSP : **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance and also according to Grubb´s test for extreme data values between labs;
LAB16 OUTLIER according to Repeated Cochran´s test for within laboratory variance.

TSP : **LAB07 OUTLIER** according to Cochran´s test for within laboratory variance and also according to Grubb´s test for extreme data values between labs.

t_{ign} (visual) : **LAB01 OUTLIER** according to Cochran´s test for within laboratory variance.

t_{ign} (5 kW) : **LAB11** and **LAB16 OUTLIERS** also according to Grubb´s test for two extreme data values between labs;

t_{ign} (3 K) : **LAB11 OUTLIER** according to Cochran´s test for within laboratory variance, and **LAB11 OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

t_v (edge) : **LAB16 OUTLIER** according to Cochran´s test for within laboratory variance.

PRODUCT M21: Steel-Clad Polystyrene Sandwich Panel

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	–	–	15
Laboratories with no erroneous data	13	13	14	14	11	11	11	11	10	–	–	2
Outliers detected in the stat. tests	0	2	2	1	1	2	1	0	0	–	–	0
Laboratories used in the stat. anal.	13	11	12	13	10	9	10	11	10	–	–	2
Level estimate m	20.4 kW	5.4 MJ	40.3 K	38695 Ks	0.612 m^2/s	253.8 m^2	80.0 s	147.6 s	584.3 s	–	–	336.6 s
Repeatability std s_r	31.0 kW	4.7 MJ	12.9 K	3470 Ks	0.909 m^2/s	199.1 m^2	17.3 s	129.0 s	136.6 s	–	–	10.0 s
Reproducibility std s_R	33.7 kW	6.1 MJ	16.0 K	5487 Ks	0.909 m^2/s	219.0 m^2	26.3 s	177.9 s	171.3 s	–	–	31.7s
Relative repeatability std s_r / m	151.8%	86.3%	32.0 %	9.0 %	148.7 %	78.4 %	21.7 %	87.4 %	23.4 %	–	–	3.0 %
Relative reproducibility std s_R / m	165.2%	112.9%	39.7 %	14.2 %	148.7 %	86.3 %	32.8 %	120.5 %	29.3 %	–	–	9.4 %
For the confidence level of 95 %												
Repeatability limit r	87.5 kW	13.3 MJ	36.5 K	9815 Ks	2.572 m^2/s	563.0 m^2	49.0 s	365.0 s	386.3 s	–	–	28.2 s
Reproducibility limit R	95.3 kW	17.3 MJ	45.4 K	15518 Ks	2.572 m^2/s	619.5 m^2	74.4 s	503.1 s	484.5 s	–	–	89.6 s
Relative repeatability limit r / m	429.4%	244.1%	90.5 %	25.4 %	420.6 %	221.9 %	61.3 %	247.3 %	66.1 %	–	–	8.4 %
Relative reproducibility limit R / m	467.3%	319.4%	112.4 %	40.1 %	420.6 %	244.1 %	92.9 %	340.9 %	82.9 %	–	–	26.6 %

ΔT : **LAB09 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB18 OUTLIER** according to Repeated Cochran's test for within laboratory variance.

cum. ΔT : **LAB09 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB01** and **LAB09 OUTLIERS** according to Grubb's test for two extreme data values between labs.

RHR : **LAB18 STRAGGLER** according to Cochran's test for within laboratory variance.

THR : **LAB09 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB18 OUTLIER** according to Repeated Cochran's test for within laboratory variance.

RSP : **LAB18 OUTLIER** according to Cochran's test for within laboratory variance and also according to Grubb's test for extreme data values between labs, and **LAB09 STRAGGLER** according to Repeated Cochran's test for within laboratory variance.

TSP : **LAB18 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB09 OUTLIER** according to Repeated Cochran's test for within laboratory variance; and **LAB09** and **LAB18 STRAGGLERS** according to Grubb's test for two extreme data values between labs

t_{ign} (visual) : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance and also according to Grubb's test for extreme data values between labs.

t_{ign} (5 kW) : **LAB11 STRAGGLER** according to Cochran's test for within laboratory variance, and **LAB16** and **LAB17 STRAGGLERS** also according to Grubb's test for two extreme data values between labs

PRODUCT M22: Ordinary Particle Board

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_{y} edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	15	15	15
Laboratories with no erroneous data	14	14	14	14	11	11	14	14	14	13	13	13
Outliers detected in the stat. tests	1	1	1	0	0	1	2	1	0	0	1	1
Laboratories used in the stat. anal.	13	13	13	14	11	10	12	13	14	13	12	12
Level estimate m	78.2 kW	52.7 MJ	120.3 K	96522 Ks	0.532 m^2/s	343.3 m^2	61.0 s	44.8 s	62.6 s	519.3 s	769.7 s	401.6 s
Repeatability std s_r	5.2 kW	4.7 MJ	5.4 K	7000 Ks	0.200 m^2/s	114.6 m^2	7.5 s	5.3 s	4.1 s	20.2 s	59.6 s	7.1 s
Reproducibility std s_R	6.6 kW	9.6 MJ	19.5 K	16473 Ks	0.380 m^2/s	261.2 m^2	14.8 s	10.3 s	8.0 s	33.6 s	198.6 s	40.6 s
Relative repeatability std s_r / m	6.7 %	8.9 %	4.4 %	7.3 %	37.5 %	33.4 %	12.3 %	11.8 %	6.5 %	3.9 %	7.7 %	1.8 %
Relative reproducibility std s_R / m	8.4 %	18.3 %	16.2 %	17.1 %	71.3 %	76.1 %	24.2 %	22.9 %	12.9 %	6.5 %	25.8 %	10.1 %
For the confidence level of 95 %												
Repeatability limit r	14.8 kW	13.2 MJ	15.1 K	19799 Ks	0.565 m^2/s	324.2 m^2	21.2 s	15.0 s	11.5 s	57.0 s	168.4 s	20.0 s
Reproducibility limit R	18.7 kW	27.3 MJ	55.0 K	46593 Ks	1.074 m^2/s	738.7 m^2	41.8 s	29.0 s	22.8 s	95.2 s	561.8 s	114.9 s
Relative repeatability limit r / m	18.9 %	25.1 %	12.6 %	20.5 %	106.2 %	94.4 %	34.8 %	33.4 %	18.3 %	11.0 %	21.9 %	5.0 %
Relative reproducibility limit R / m	23.9 %	51.8 %	45.8 %	48.3 %	201.6 %	215.1 %	68.5 %	64.7 %	36.4 %	18.3 %	73.0 %	28.6 %

ΔT : **LAB18 OUTLIER** according to Cochran's test for within laboratory variance.

RHR : **LAB09 OUTLIER** according to Grubb's test for extreme data values between labs, **and LAB11 STRAGGLER** according to Cochran's test for within laboratory variance.

THR : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance.

TSP : **LAB07 OUTLIER** according to Grubb's test for extreme data values between labs , **and LAB14 STRAGGLER** according to Cochran's test for within laboratory variance.

t_{ign} (visual) **LAB10 OUTLIER** according to Cochran's test for within laboratory variance and also according to Grubb's test for extreme data values between labs;
LAB11 OUTLIER according to Repeated Cochran's test for within laboratory variance.

t_{ign} (5 kW) : **LAB02 OUTLIER** according to Cochran's test for within laboratory variance.

t_{x1} (250 mm) : **LAB17 STRAGGLER** according to Cochran's test for within laboratory variance, and **LAB06 STRAGGLER** according to Grubb's test for extreme data values between labs.

t_{x2} (350 mm) : **LAB10 OUTLIER**according to Cochran's test for within laboratory variance, and **LAB11 STRAGGLER** according to Grubb's test for extreme data values between labs.

t_{y} (edge) : **LAB10 OUTLIER**according to Cochran's test for within laboratory variance.

PRODUCT M23: Ordinary Plywood (Birch)

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	15	15	15
Laboratories with no erroneous data	15	15	15	15	12	12	15	15	15	13	11	14
Outliers detected in the stat. tests	0	1	0	0	2	2	2	0	0	3	0	0
Laboratories used in the stat. anal.	15	14	15	15	10	10	13	15	15	10	11	14
Level estimate *m*	69.1 kW	47.6 MJ	112.1 K	88489 Ks	0.294 m^2/s	148.5 m^2	49.2 s	36.4 s	49.9 s	524.2 s	1022.6 s	385.0 s
Repeatability std s_r	10.7 kW	3.3 MJ	12.1 K	3803 Ks	0.056 m^2/s	28.5 m^2	6.7 s	5.3 s	3.4 s	48.3 s	145.8 s	10.4 s
Reproducibility std s_R	12.4 kW	5.4 MJ	20.0 K	14539 Ks	0.287 m^2/s	77.9 m^2	8.1 s	10.2 s	7.9 s	50.4 s	292.2 s	45.8 s
Relative repeatability std s_r / m	15.5 %	6.9 %	10.8 %	4.3 %	19.1 %	19.2 %	13.6 %	14.6 %	6.9 %	9.2 %	14.3 %	2.7 %
Relative reproducibility std s_R / m	17.9 %	11.3 %	17.8 %	16.4 %	97.8 %	52.5 %	16.5 %	28.1 %	15.8 %	9.6 %	28.6 %	11.9 %
For the confidence level of 95 %												
Repeatability limit *r*	30.2 kW	9.3 MJ	34.4 K	10756 Ks	0.159 m^2/s	80.7 m^2	18.9 s	15.0 s	9.7 s	136.6 s	412.5 s	29.4 s
Reproducibility limit *R*	35.0 kW	15.2 MJ	56.5 K	41122 Ks	0.813 m^2/s	220.4 m^2	23.0 s	28.9 s	22.3 s	142.6 s	826.4 s	129.6 s
Relative repeatability limit r / m	43.8 %	19.5 %	30.6 %	12.2 %	54.1 %	54.3 %	38.4 %	41.3 %	19.4 %	26.1 %	40.3 %	7.6 %
Relative reproducibility limit R / m	50.7 %	31.9 %	50.4 %	46.5 %	276.7 %	148.4 %	46.8 %	79.4 %	44.7 %	27.2 %	80.8 %	33.7 %

cum. ΔT : **LAB03 STRAGGLER**according to Grubb's test for extreme data values between labs.

RHR : **LAB03 OUTLIER** according to Grubb's test for extreme data values between labs.

RSP : **LAB16 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB14 OUTLIER** according to Repeated Cochran's test for within laboratory variance; **LAB07** and **LAB16 STRAGGLERS** according to Grubb's test for extreme data values between labs.

TSP : **LAB16 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB01 OUTLIER** according to Repeated Cochran's test for within laboratory variance; **LAB07** and **LAB16 STRAGGLERS** according to Grubb's test for two extreme data values between labs

t_{ign} (visual) : **LAB10 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB04 OUTLIER** according to Repeated Cochran's test for within laboratory variance; **LAB04** and **LAB10 OUTLIERS** also according to Grubb's test for extreme data values between labs.

t_{x1} (250 mm) : **LAB04 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB05 OUTLIER** according to Repeated Cochran's test for within laboratory variance; **LAB18 OUTLIER** also according to Grubb's test for extreme data values between labs.

t_{x2} (350 mm) : **LAB04 STRAGGLER** according to Cochran's test for within laboratory variance.

PRODUCT M24: Paper Wallcovering on Particle Board

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	15	15	15
Laboratories with no erroneous data	15	15	15	15	12	12	15	15	15	14	9	14
Outliers detected in the stat. tests	1	1	0	0	2	2	2	1	1	0	2	0
Laboratories used in the stat. anal.	14	14	15	15	10	10	13	14	14	14	7	14
Level estimate m	81.1 kW	49.6 MJ	121.5 K	93182 Ks	0.317 m^2/s	209.1 m^2	39.1 s	34.6 s	49.0 s	498.5 s	1143.2 s	374.1 s
Repeatability std s_r	6.1 kW	6.3 MJ	7.4 K	6544 Ks	0.126 m^2/s	80.5 m^2	6.5 s	3.7 s	5.4 s	47.4 s	77.5 s	7.6 s
Reproducibility std s_R	6.9 kW	8.4 MJ	15.7 K	13966 Ks	0.181 m^2/s	119.7 m^2	9.9 s	8.0 s	8.7 s	54.5 s	630.6 s	30.2 s
Relative repeatability std s_r / m	7.5 %	12.6 %	6.1 %	7.0 %	39.8 %	38.5 %	16.6 %	10.8 %	11.0 %	9.5 %	6.8 %	2.0 %
Relative reproducibility std s_R / m	8.4 %	17.0 %	12.9 %	15.0 %	57.2 %	57.2 %	25.3 %	23.0 %	17.7 %	10.9 %	55.2 %	8.1 %
For the confidence level of 95 %												
Repeatability limit r	17.2 kW	17.7 MJ	20.9 K	18508 Ks	0.357 m^2/s	227.6 m^2	18.3 s	10.6 s	15.2 s	134.2 s	219.3 s	21.6 s
Reproducibility limit R	19.4 kW	23.8 MJ	44.3 K	39502 Ks	0.513 m^2/s	338.4 m^2	28.0 s	22.5 s	24.5 s	154.2 s	1783.6 s	85.3 s
Relative repeatability limit r / m	21.2 %	35.7 %	17.2 %	19.9 %	112.6 %	108.8 %	46.9 %	30.5 %	31.0 %	26.9 %	19.2 %	5.8 %
Relative reproducibility limit R / m	23.9 %	48.0 %	36.5 %	42.4 %	161.9 %	161.8 %	71.6 %	65.2 %	50.0 %	30.9 %	156.0 %	22.8 %

RHR : **LAB11 OUTLIER** according to Grubb´s test for extreme data values between labs.

THR : **LAB11 OUTLIER** according to Grubb´s test for extreme data values between labs.

RSP : **LAB18 OUTLIER** according to Cochran´s test for within laboratory variance, and **LAB06 STRAGGLER** according to Repeated Cochran´s test for within laboratory variance; **LAB07** and **LAB18 OUTLIERS** according to Grubb´s test for extreme data values between labs.

TSP : **LAB18 OUTLIER** according to Cochran´s test for within laboratory variance, and **LAB06 STRAGGLER** according to Repeated Cochran´s test for within laboratory variance; **LAB07** and **LAB18 OUTLIERS** according to Grubb´s test for extreme data values between labs.

t_{ign} (visual) : **LAB10 OUTLIER** according to Cochran´s test for within laboratory variance, and **LAB04 OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

t_{ign} (5 kW) : **LAB11 OUTLIER** according to Cochran´s test for within laboratory variance, and **OUTLIER** also according to Grubb´s test for extreme data values between labs.

t_{ign} (3 K) : **LAB11 OUTLIER** according to Cochran´s test for within laboratory variance.

t_{x2} (350 mm) : **LAB09 OUTLIER** according to Cochran´s test for within laboratory variance, and **LAB06 OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

PRODUCT M25: Medium Density Fibreboard

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	15	15	15
Laboratories with no erroneous data	15	15	15	15	12	12	15	15	15	14	14	14
Outliers detected in the stat. tests	0	1	0	1	1	1	0	1	0	0	0	1
Laboratories used in the stat. anal.	15	14	15	14	11	11	15	14	15	14	14	13
Level estimate m	125.9 kW	88.0 MJ	202.2 K	144063 Ks	0.474 m2/s	277.5 m2	67.4 s	47.2 s	64.4 s	515.0 s	791.9 s	389.5 s
Repeatability std s_r	15.7 kW	5.6 MJ	20.9 K	6422 Ks	0.345 m2/s	164.6 m2	11.3 s	4.2 s	4.1 s	21.5 s	104.6 s	10.2 s
Reproducibility std s_R	28.6 kW	10.5 MJ	46.2 K	22064 Ks	0.541 m2/s	243.7 m2	15.5 s	8.1 s	7.1 s	36.8 s	156.5 s	35.8 s
Relative repeatability std s_r / m	12.5 %	6.4 %	10.3 %	4.5 %	72.9 %	59.3 %	16.8 %	8.9 %	6.4 %	4.2 %	13.2 %	2.6 %
Relative reproducibility std s_R / m	22.7 %	11.9 %	22.8 %	15.3 %	114.2 %	87.8 %	23.0 %	17.0 %	11.0 %	7.1 %	19.8 %	9.2 %
For the confidence level of 95 %												
Repeatability limit r	44.5 kW	15.8 MJ	59.1 K	18164 Ks	0.977 m2/s	465.6 m2	31.9 s	11.9 s	11.6 s	60.7 s	296.0 s	29.0 s
Reproducibility limit R	80.9 kW	29.7 MJ	130.7 K	62406 Ks	1.530 m2/s	689.2 m2	43.9 s	22.8 s	20.0 s	103.9 s	442.7 s	101.3 s
Relative repeatability limit r / m	35.3 %	18.0 %	29.2 %	12.6 %	206.1 %	167.8 %	47.4 %	25.2 %	18.1 %	11.8 %	37.4 %	7.4 %
Relative reproducibility limit R / m	64.2 %	33.8 %	64.6 %	43.3 %	323.0 %	248.3 %	65.1 %	48.2 %	31.1 %	20.2 %	55.9 %	26.0 %

ΔT : **LAB01 STRAGGLER** according to Cochran's test for within laboratory variance.
cum. ΔT : **LAB01 OUTLIER** according to Cochran's test for within laboratory variance.
RHR : LAB10 and LAB11 **STRAGGLERS** according to Grubb's test for two extreme data values between labs.
THR : **LAB11 OUTLIER** according to Grubb's test for extreme data values between labs.
RSP : **LAB16 OUTLIER** according to Grubb's test for extreme data values between labs and also **LAB18 STRAGGLER** according to Cochran's test for within laboratory variance.
TSP : **LAB16 OUTLIER** according to Grubb's test for extreme data values between labs and also **STRAGGLER** according to Cochran's test for within laboratory variance.
t_{ign} (5 kW) : **LAB11 OUTLIER** according to Cochran's test for within laboratory variance, and **OUTLIER** also according to Grubb's test for extreme data values between labs.
t_{ign} (3 K) : **LAB11 STRAGGLER** according to Cochran's test for within laboratory variance.
t_{x1} (250 mm) : **LAB06** and **LAB12 STRAGGLERS** according to Grubb's test for two extreme data values between labs.
t_{x2} (350 mm) : **LAB10 STRAGGLER** according to Cochran's test for within laboratory variance.
t_v (edge) : **LAB09 OUTLIER** according to Cochran's test for within laboratory variance.

PRODUCT M26: Low Density Fibreboard

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	15	15	15
Laboratories with no erroneous data	14	14	14	14	12	12	14	13	14	13	13	13
Outliers detected in the stat. tests	0	1	0	0	2	2	0	1	1	0	1	1
Laboratories used in the stat. anal.	14	13	14	14	10	10	14	12	13	13	12	12
Level estimate m	132.8 kW	95.8 MJ	163.8 K	135918 Ks	0.759 m2/s	319.0 m2	18.4 s	15.8 s	20.2 s	360.8 s	425.0 s	331.6 s
Repeatability std s_r	17.8 kW	5.0 MJ	20.8 K	8644 Ks	0.421 m2/s	131.1 m2	2.9 s	2.1 s	1.7 s	6.0 s	8.9 s	3.3 s
Reproducibility std s_R	23.3 kW	9.9 MJ	37.0 K	22746 Ks	0.441 m2/s	177.5 m2	6.0 s	8.8 s	4.5 s	11.8 s	21.6 s	10.1 s
Relative repeatability std s_r / m	13.4 %	5.2 %	12.7 %	6.4 %	55.5 %	41.1 %	15.8 %	13.2 %	8.5 %	1.7 %	2.1 %	1.0 %
Relative reproducibility std s_R / m	17.5 %	10.3 %	22.6 %	16.7 %	58.1 %	55.6 %	32.6 %	55.5 %	22.4 %	3.3 %	5.1 %	3.0 %
For the confidence level of 95 %												
Repeatability limit r	50.3 kW	14.0 MJ	58.7 K	24449 Ks	1.192 m2/s	370.8 m2	8.2 s	5.9 s	4.8 s	16.8 s	25.1 s	9.4 s
Reproducibility limit R	65.8 kW	28.0 MJ	104.5 K	64337 Ks	1.247 m2/s	501.9 m2	17.0 s	24.8 s	12.8 s	33.5 s	61.0 s	28.6 s
Relative repeatability limit r / m	37.9 %	14.7 %	35.8 %	18.0 %	157.1 %	116.2 %	44.6 %	37.4 %	23.9 %	4.7 %	5.9 %	2.8 %
Relative reproducibility limit R / m	49.5 %	29.2 %	63.8 %	47.3 %	164.3 %	157.4 %	92.3 %	157.0 %	63.4 %	9.3 %	14.4 %	8.6 %

RHR : LAB07 **STRAGGLER** according to Cochran's test for within laboratory variance.
THR : **LAB18 OUTLIER** according to Cochran's test for within laboratory variance.
RSP : **LAB07** and **LAB16 OUTLIERS** according to Grubb's test for two extreme data values between labs..
TSP : **LAB07** and **LAB16 OUTLIERS** according to Grubb's test for two extreme data values between labs..
t_{ign} (visual) : **LAB03** and **LAB07 STRAGGLERS** according to Grubb's test for two extreme data values between labs.
t_{ign} (5 kW) : **LAB02 OUTLIER** according to Cochran's test for within laboratory variance.
t_{ign} (3 K) : **LAB02 OUTLIER** according to Cochran's test for within laboratory variance, and **LAB09** and **LAB16 STRAGGLERS** according to Grubb's test for two extreme data values between labs .
t_{x2} (250 mm) : **LAB06** and **LAB10 STRAGGLERS** according to Grubb's test for two extreme data values between labs.
t_{x2} (350 mm) : **LAB09 OUTLIER** according to Cochran's test for within laboratory variance.
t_v (edge) : **LAB10 OUTLIER** according to Cochran's test for within laboratory variance.

PRODUCT M27: Gypsum Plasterboard / PUR Foam Core

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	–	–	15
Laboratories with no erroneous data	15	15	15	15	14	14	10	15	12	–	–	2
Outliers detected in the stat. tests	1	0	0	1	1	2	1	3	0	–	–	0
Laboratories used in the stat. anal.	14	15	15	14	13	12	9	12	12	–	–	2
Level estimate m	5.7 kW	2.9 MJ	33.4 K	35276 Ks	0.149 m^2/s	114.8 m^2	691.2 s	76.5 s	1029.3 s	–	–	324.7 s
Repeatability std s_r	1.0 kW	1.0 MJ	1.2 K	567 Ks	0.032 m^2/s	11.4 m^2	62.5 s	17.1 s	87.7 s	–	–	10.2 s
Reproducibility std s_R	1.0 kW	1.1 MJ	3.3 K	2909 Ks	0.049 m^2/s	32.0 m^2	501.9 s	20.3 s	137.2 s	–	–	18.9 s
Relative repeatability std s_r / m	17.3 %	34.8 %	3.5 %	1.6 %	21.2 %	9.9 %	9.0 %	22.4 %	8.5 %	–	–	3.1 %
Relative reproducibility std s_R / m	18.4 %	39.2 %	9.9 %	8.2 %	32.5 %	27.9 %	72.6 %	26.5 %	13.3 %	–	–	5.8 %
For the confidence level of 95 %												
Repeatability limit r	2.8 kW	2.9 MJ	3.3 K	1604 Ks	0.090 m^2/s	32.2 m^2	176.7 s	48.4 s	247.9 s	–	–	28.8 s
Reproducibility limit R	3.0 kW	3.2 MJ	9.3 K	8228 Ks	0.137 m^2/s	90.5 m^2	1419.5 s	57.3 s	388.0 s	–	–	53.4 s
Relative repeatability limit r / m	49.0 %	98.4 %	10.0 %	4.5 %	59.9 %	28.1 %	25.6 %	63.2 %	24.1 %	–	–	8.9 %
Relative reproducibility limit R / m	52.2 %	110.8 %	27.9 %	23.3 %	92.0 %	78.8 %	205.4 %	75.0 %	37.7 %	–	–	16.5 %

ΔT : LAB11 **STRAGGLER** according to Cochran's test for within laboratory variance.
cum. ΔT : LAB11 **OUTLIER** according to Cochran's test for within laboratory variance.
RHR : LAB07 **OUTLIER** according to Grubb's test for extreme data values between labs.
THR : LAB12 **STRAGGLER** according to Cochran's test for within laboratory variance.
RSP : LAB16 **OUTLIER** according to Cochran's test for within laboratory variance and also according to Grubb's test for extreme data values between labs
TSP : LAB16 **OUTLIER** according to Cochran's test for within laboratory variance, LAB01 **OUTLIER** according to Repeated Cochran's test for within laboratory variance, and **LAB09** and **LAB16 STRAGGLERS** according to Grubb's test for two extreme data values between labs.
t_{ign} (visual) : LAB09 **OUTLIER** according to Cochran's test for within laboratory variance.
t_{ign} (5 kW) : LAB12 **OUTLIER** according to Cochran's test for within laboratory variance, LAB01 **OUTLIER** according to Repeated Cochran's test for within laboratory variance, and **LAB11 OUTLIER** according to 3rd Cochran's test[*] for within laboratory variance; **LAB01** and **LAB12 STRAGGLERS** according to Grubb's test for two extreme data values between labs.
t_{ign} (3 K) : LAB12 **STRAGGLER** according to Cochran's test for within laboratory variance.

[*] Here the Cochran's test was exceptionally applied also the third time since in the second test, the Cochran's test quantities of LAB01 and LAB11 were practically equal

PRODUCT M28: Acoustic Mineral Fibre Tiles

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	–	–	15
Laboratories with no erroneous data	15	15	15	15	14	14	3	14	10	–	–	2
Outliers detected in the stat. tests	0	0	0	0	1	1	0	0	0	–	–	0
Laboratories used in the stat. anal.	15	15	15	15	13	13	3	14	10	–	–	2
Level estimate m	5.2 kW	2.3 MJ	33.2 K	37370 Ks	0.119 m^2/s	117.2 m^2	421.9 s	16.7 s	673.0 s	–	–	315.8 s
Repeatability std s_r	0.78 kW	0.70 MJ	0.77 K	754 Ks	0.019 m^2/s	19.3 m^2	7.0 s	2.8 s	199.6 s	–	–	3.5 s
Reproducibility std s_R	1.0 kW	1.0 MJ	3.7 K	4126 Ks	0.044 m^2/s	45.5 m^2	674.2 s	8.0 s	268.1 s	–	–	9.0 s
Relative repeatability std s_r / m	15.0 %	30.6 %	2.3 %	2.0 %	15.6 %	16.5 %	1.7 %	16.8 %	29.7 %	–	–	1.1 %
Relative reproducibility std s_R / m	18.6 %	42.8 %	11.2 %	11.0 %	36.6 %	38.8 %	159.8 %	48.0 %	39.8 %	–	–	2.9 %
For the confidence level of 95 %												
Repeatability limit r	2.2 kW	2.0 MJ	2.2 K	2132 Ks	0.053 m^2/s	54.5 m^2	19.8 s	7.9 s	564.5 s	–	–	10.0 s
Reproducibility limit R	2.7 kW	2.8 MJ	10.5 K	11671 Ks	0.124 m^2/s	128.6 m^2	1906.8 s	22.6 s	758.4 s	–	–	25.5 s
Relative repeatability limit r / m	42.4 %	86.5 %	6.6 %	5.7 %	44.1 %	46.5 %	4.7 %	47.6 %	83.9 %	–	–	3.2 %
Relative reproducibility limit R / m	52.7 %	121.2 %	31.7 %	31.2 %	103.6 %	109.8 %	452.0 %	135.8 %	112.7 %	–	–	8.1 %

ΔT : **LAB04 STRAGGLER** according to Cochran´s test for within laboratory variance.
cum. ΔT : **LAB04 STRAGGLER** according to Cochran´s test for within laboratory variance.
RSP : LAB07 **OUTLIER** according to Cochran´s test for within laboratory variance.
TSP : LAB07 **OUTLIER** according to Cochran´s test for within laboratory variance, LAB05 **STRAGGLER** according to Repeated Cochran´s test for within laboratory variance.
t_{ign} (5 kW) : **LAB02 STRAGGLER** according to Cochran´s test for within laboratory variance.

PRODUCT M29: Textile Wallpaper on CaSi Board

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_v edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	15	–	15
Laboratories with no erroneous data	14	14	14	14	13	13	13	14	14	2	–	4
Outliers detected in the stat. tests	0	0	0	1	2	2	1	0	0	0	–	1
Laboratories used in the stat. anal.	14	14	14	13	11	11	12	14	14	2	–	3
Level estimate m	11.8 kW	4.4 MJ	35.2 K	36918 Ks	0.131 m^2/s	120.3 m^2	47.7 s	33.9 s	48.9 s	1219.8 s	–	360.6 s
Repeatability std s_r	1.3 kW	1.0 MJ	0.91 K	727 Ks	0.027 m^2/s	24.5 m^2	14.8 s	4.8 s	3.9 s	254.3 s	–	21.1 s
Reproducibility std s_R	1.6 kW	1.3 MJ	3.6 K	3254 Ks	0.051 m^2/s	50.9 m^2	17.5 s	8.9 s	7.0 s	277.8 s	–	23.1 s
Relative repeatability std s_r / m	11.2 %	22.3 %	2.6 %	2.0 %	20.2 %	20.4 %	31.0 %	14.2 %	8.0 %	20.8 %	–	5.9 %
Relative reproducibility std s_R / m	13.2 %	28.9 %	10.2 %	8.8 %	38.5 %	42.3 %	36.7 %	26.2 %	14.4 %	22.8 %	–	6.4 %
For the confidence level of 95 %												
Repeatability limit r	3.7 kW	2.7 MJ	2.6 K	2056 Ks	0.075 m^2/s	69.3 m^2	41.8 s	13.6 s	11.1 s	719.3 s	–	59.7 s
Reproducibility limit R	4.4 kW	3.6 MJ	10.2 K	9204 Ks	0.143 m^2/s	144.0 m^2	49.4 s	25.2 s	19.9 s	785.8 s	–	65.3 s
Relative repeatability limit r / m	31.6 %	63.1 %	7.3 %	5.6 %	57.0 %	57.6 %	87.7 %	40.2 %	22.7 %	59.0 %	–	16.6 %
Relative reproducibility limit R / m	37.2 %	81.7 %	28.9 %	24.9 %	108.9 %	119.7 %	103.7 %	74.2 %	40.8 %	64.4 %	–	18.1 %

ΔT : **LAB09 STRAGGLER** according to Cochran´s test for within laboratory variance.

cum. ΔT : **LAB11 OUTLIER** according to Cochran´s test for within laboratory variance.

THR : **LAB11** and **LAB18 STRAGGLERS** according to Grubb´s test for two extreme data values between labs.

RSP : LAB16 **OUTLIER** according to Cochran´s test for within laboratory variance and also according to Grubb´s test for extreme data values between labs; LAB18 **OUTLIER** according to Repeated Cochran´s test for within laboratory variance.

TSP : LAB16 **OUTLIER** according to Cochran´s test for within laboratory variance, LAB18 **OUTLIER** according to Repeated Cochran´s test for within laboratory variance, and LAB16 also **STRAGGLER** according to Grubb´s test for extreme data values between labs.

t_{ign} (visual) : **LAB04 OUTLIER** according to Grubb´s test for extreme data values between labs.

t_{ign} (5 kW) : **LAB03 STRAGGLER** according to Cochran´s test for within laboratory variance.

t_{ign} (3 K) : **LAB09 STRAGGLER** according to Grubb´s test for extreme data values between labs.

t_v (edge) : **LAB10 OUTLIER** according to Cochran´s test for within laboratory variance and also **STRAGGLER** according to Grubb´s test for extreme data values between labs.

PRODUCT M30: Paper-Faced Glass Wool

Quantity analyzed	RHR	THR	ΔT	cum. ΔT	RSP	TSP	t_{ign} visual	t_{ign} 5 kW	t_{ign} 3 K	t_{x1} 250 mm	t_{x2} 350 mm	t_y edge
Laboratories reporting results	15	15	15	15	15	15	15	15	15	15	15	15
Laboratories with no erroneous data	14	14	14	14	12	12	14	14	14	13	13	10
Outliers detected in the stat. tests	0	0	0	0	1	1	1	0	0	2	1	0
Laboratories used in the stat. anal.	14	14	14	14	11	11	13	14	14	11	12	10
Level estimate m	95.0 kW	9.0 MJ	114.0 K	45267 Ks	0.169 m2/s	146.3 m2	6.7 s	7.7 s	10.4 s	316.9 s	323.5 s	311.8 s
Repeatability std s_r	4.4 kW	1.2 MJ	4.5 K	1615 Ks	0.039 m2/s	28.4 m2	2.0 s	1.7 s	1.4 s	1.9 s	2.6 s	2.1 s
Reproducibility std s_R	7.2 kW	1.6 MJ	14.2 K	5478 Ks	0.086 m2/s	73.4 m2	2.7 s	7.2 s	3.7 s	2.8 s	3.7 s	3.4 s
Relative repeatability std s_r / m	4.7 %	13.4 %	3.9 %	3.6 %	23.1 %	19.4 %	29.5 %	22.4 %	13.0 %	0.6 %	0.8 %	0.7 %
Relative reproducibility std s_R / m	7.6 %	18.1 %	12.5 %	12.1 %	50.8 %	50.2 %	41.1 %	93.2 %	35.4 %	0.9 %	1.1 %	1.1 %
For the confidence level of 95 %												
Repeatability limit r	12.5 kW	3.4 MJ	12.6 K	4568 Ks	0.110 m2/s	80.4 m2	5.6 s	4.9 s	3.8 s	5.3 s	7.3 s	6.0 s
Reproducibility limit R	20.4 kW	4.6 MJ	40.3 K	15493 Ks	0.242 m2/s	207.5 m2	7.8 s	20.3 s	10.4 s	7.9 s	10.3 s	9.5 s
Relative repeatability limit r / m	13.2 %	37.9 %	11.0 %	10.1 %	65.2 %	55.0 %	83.5 %	63.4 %	36.8 %	1.7 %	2.3 %	1.9 %
Relative reproducibility limit R / m	21.5 %	51.2 %	35.3 %	34.2 %	143.7 %	141.9 %	116.4 %	263.6 %	100.3 %	2.5 %	3.2 %	3.0 %

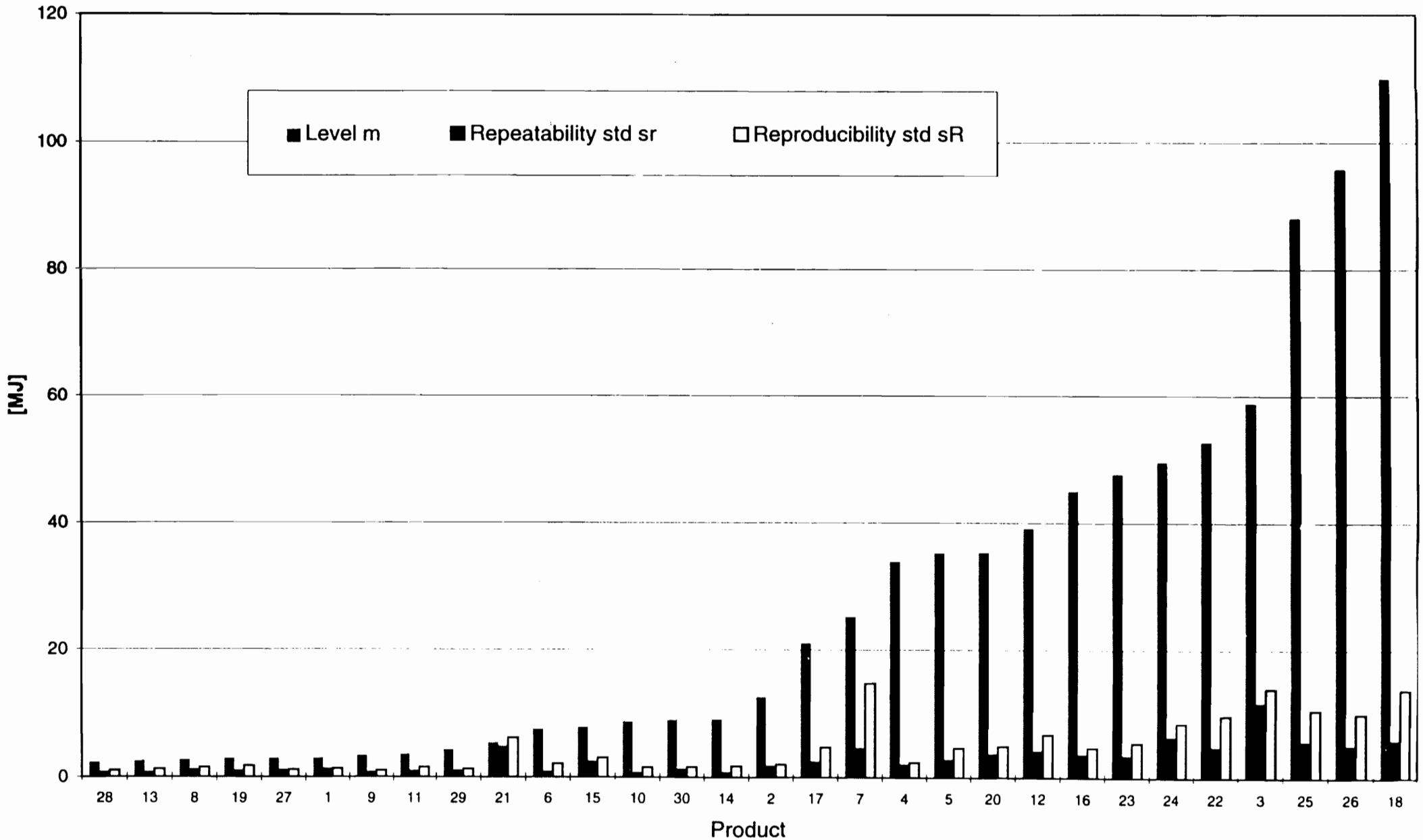
RSP : LAB16 **OUTLIER** according to Cochran´s test for within laboratory variance and **LAB01** and **LAB09 STRAGGLERS** according to Grubb´s test for extreme data values between labs

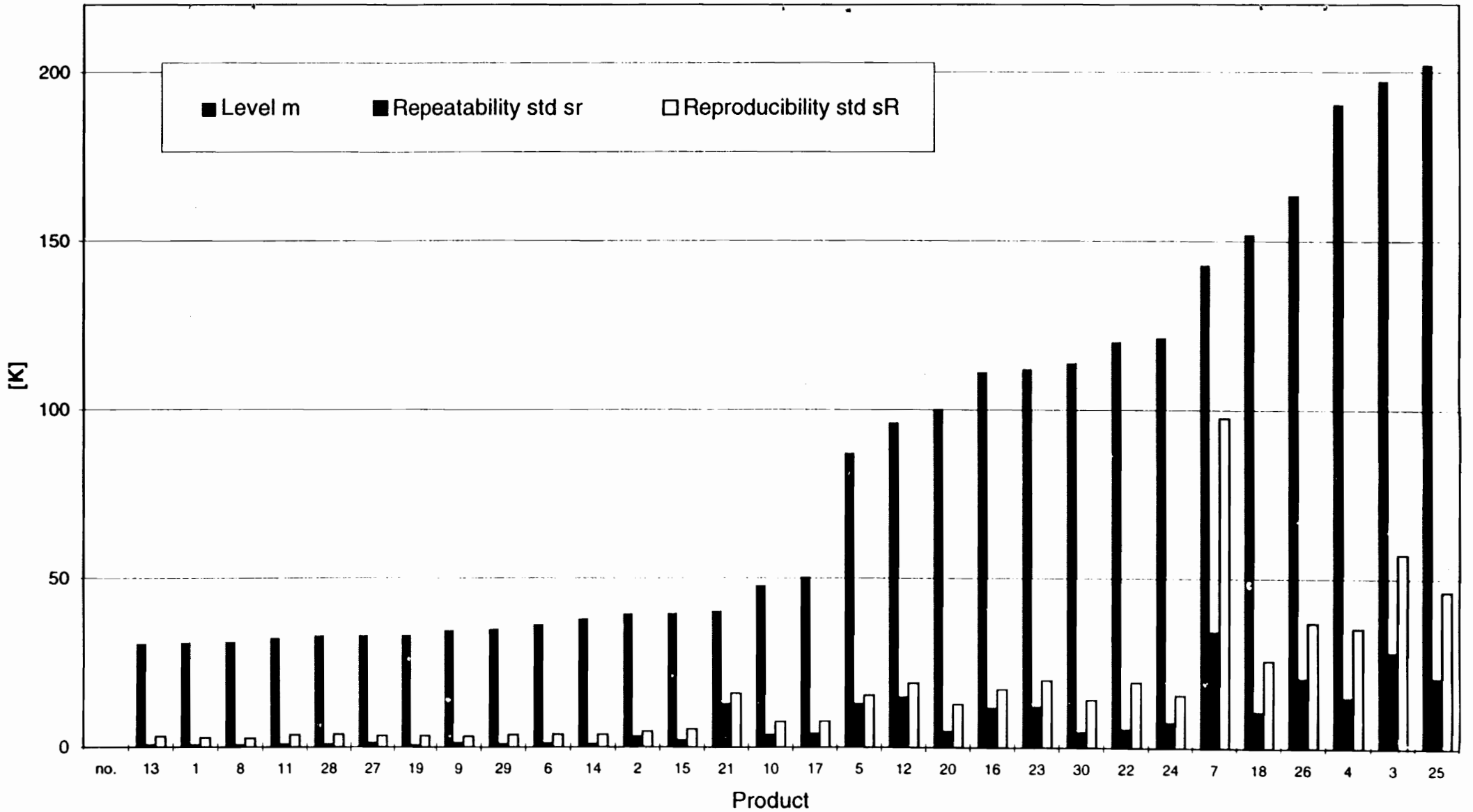
TSP : LAB16 **OUTLIER** according to Cochran´s test for within laboratory variance.

t_{ign} (visual) : **LAB06 OUTLIER** according to Cochran´s test for within laboratory variance and also according to Grubb´s test for extreme data values between labs;
LAB12 STRAGGLER according to Repeated Cochran´s test for within laboratory variance.

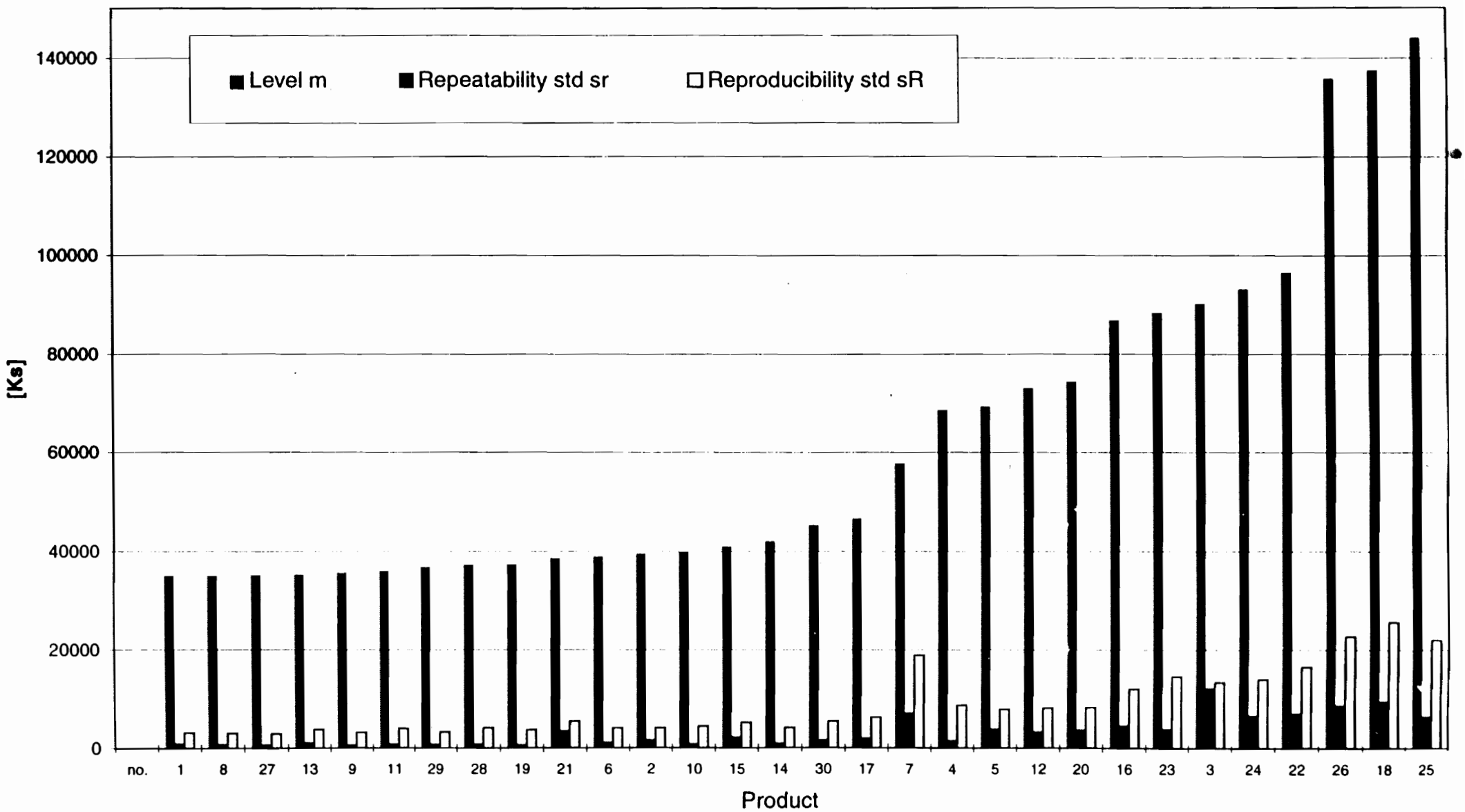
t_{x1} (250 mm) : **LAB12 OUTLIER** according to Cochran´s test for within laboratory variance and also according to Grubb´s test for extreme data values between labs;
LAB 04 OUTLIER according to Repeated Cochran´s test for within laboratory variance..

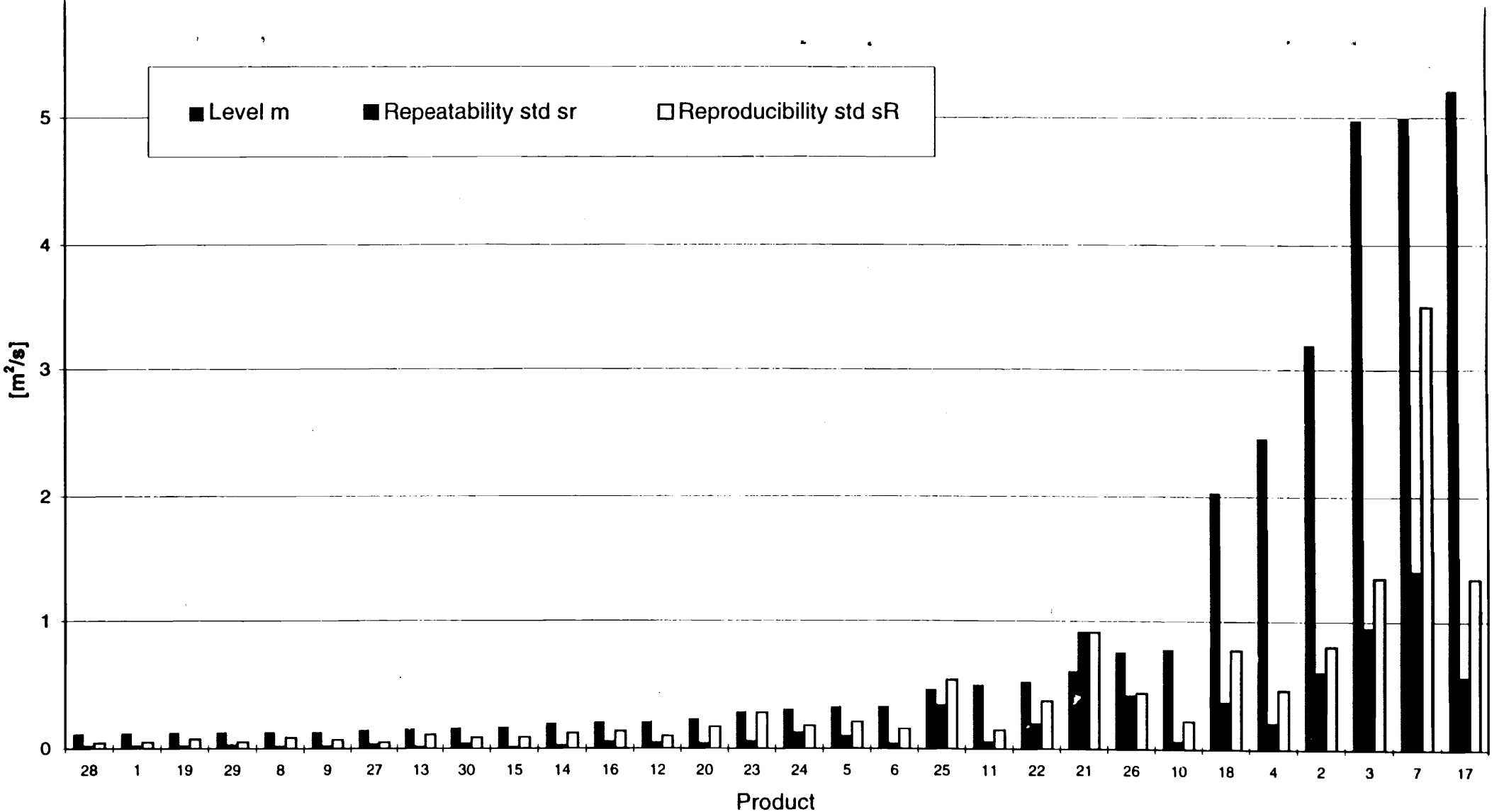
t_{x2} (350 mm) : **LAB 04 OUTLIER** according to Cochran´s test for within laboratory variance and **LAB16 STRAGGLER** according to Repeated Cochran´s test for within laboratory variance

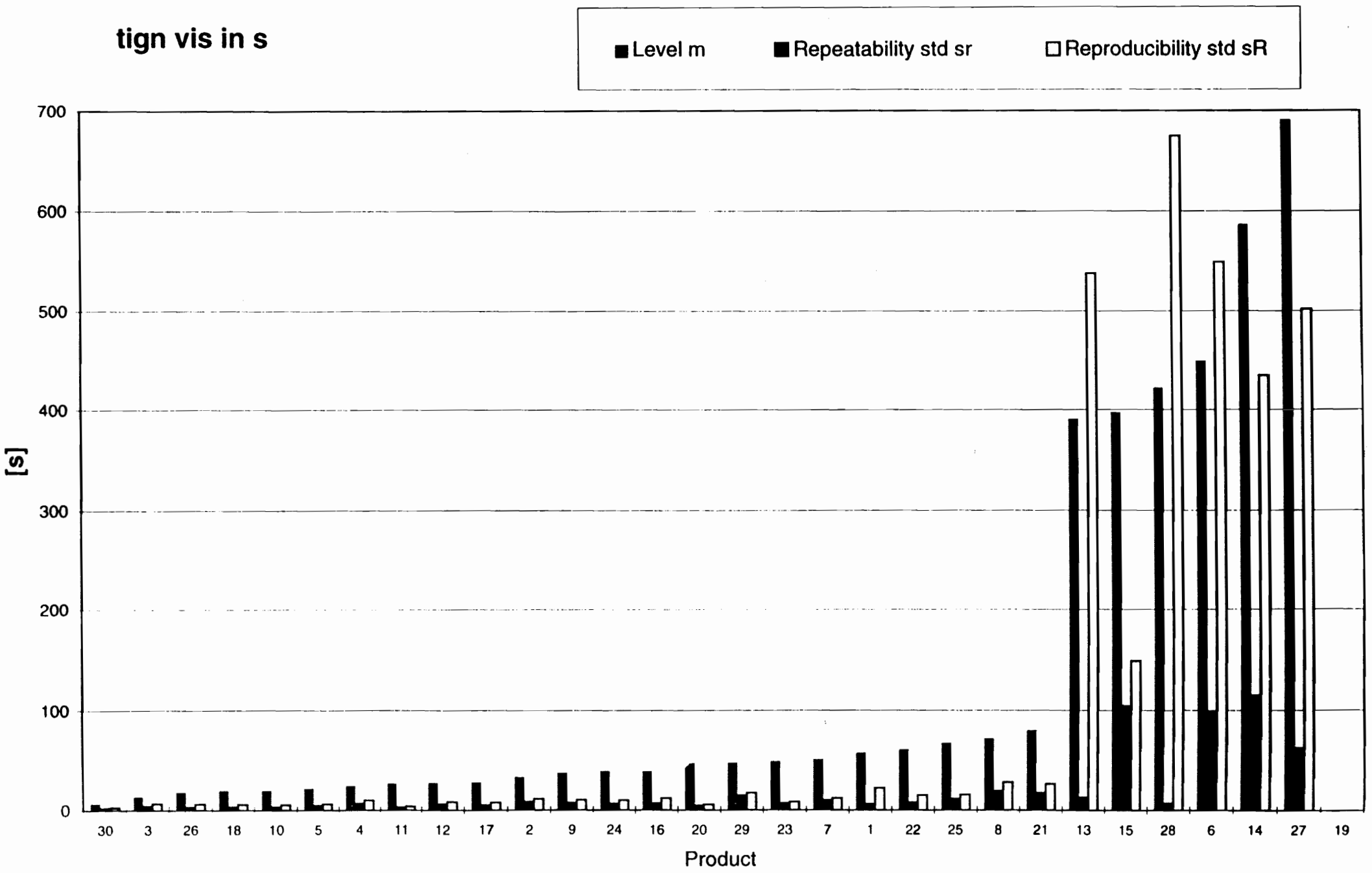

THR in MJ
Level m
Repeatability std sr
Reproducibility std sR
[MJ]
120
100
80
60
40
20
0
28 13 8 19 27 1 9 11 29 21 6 15 10 30 14 2 17 7 4 5 20 12 16 23 24 22 3 25 26 18
Product


Level m
Repeatability std sr
Reproducibility std sR
200
150
100
50
0
[K]
no.
13
1
8
11
28
27
19
9
29
6
14
2
15
21
10
17
5
12
20
16
23
30
22
24
7
18
26
4
3
25
Product

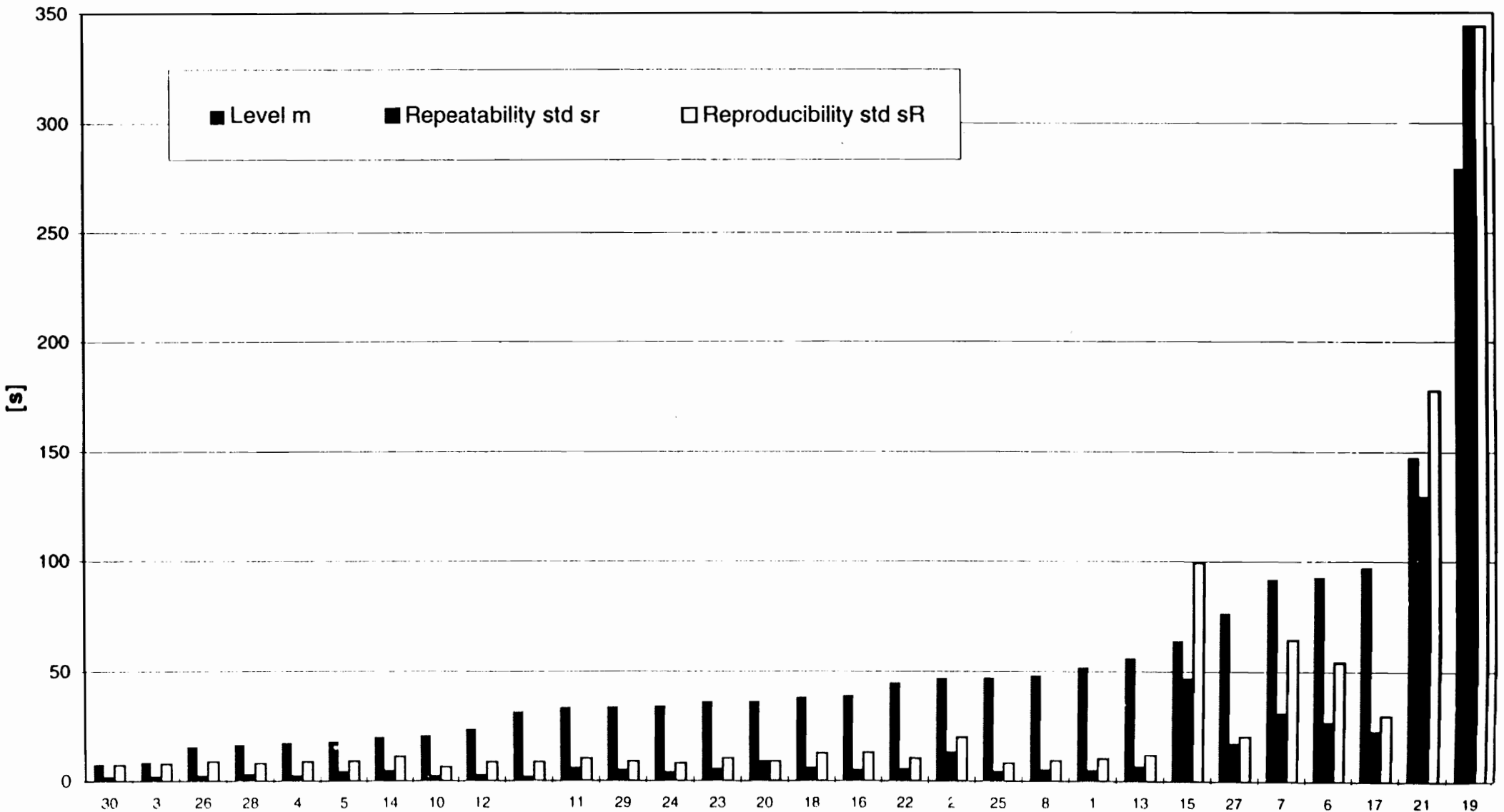
cum. ΔT in Ks

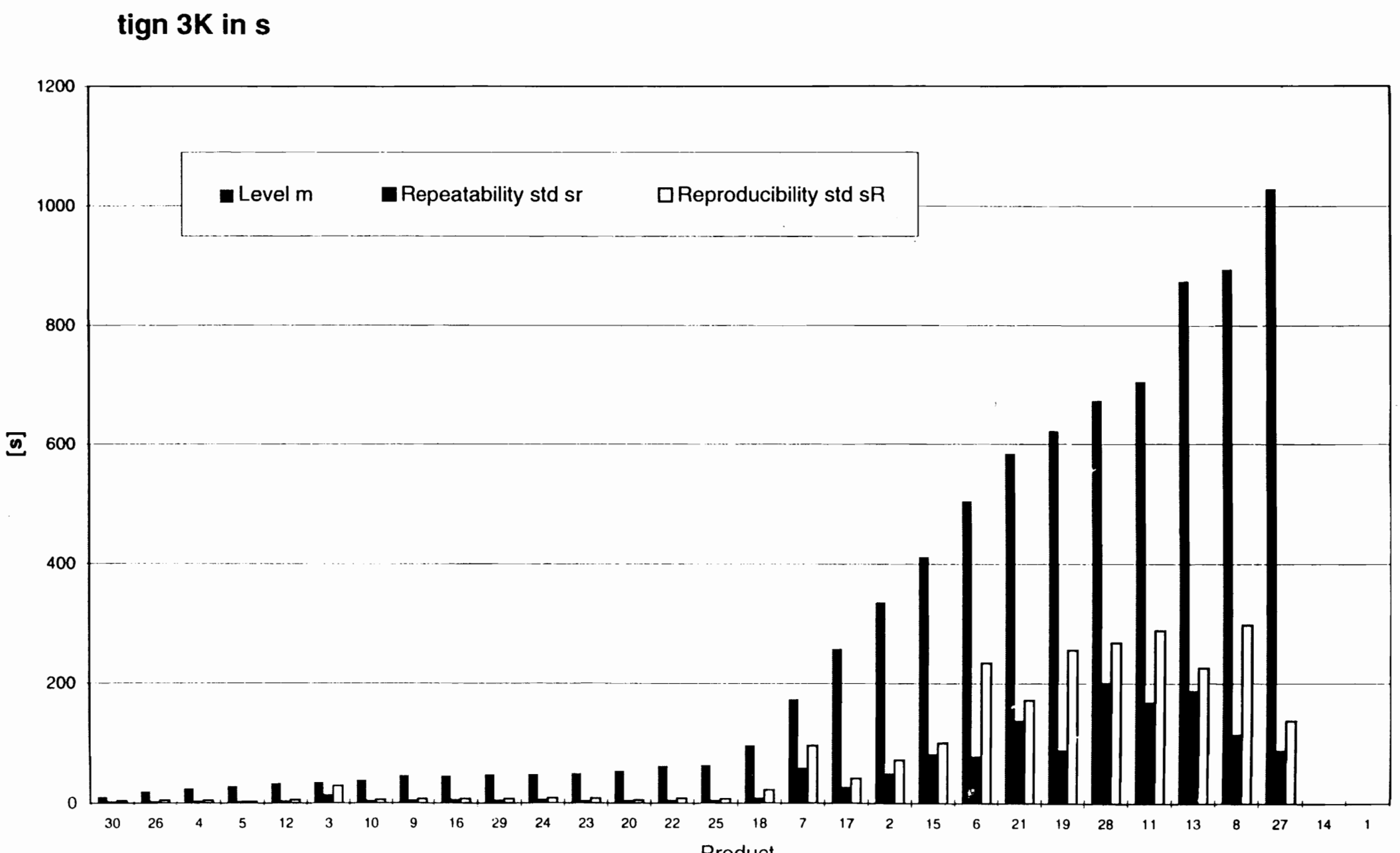

Level m
Repeatability std sr
Reproducibility std sR
140000
120000
100000
80000
60000
40000
20000
0
[Ks]
no. 1 8 27 13 9 11 29 28 19 21 6 2 10 15 14 30 17 7 4 5 12 20 16 23 3 24 22 26 18 25
Product


Level m
Repeatability std sr
Reproducibility std sR
[m²/s]
0
1
2
3
4
5
28 1 19 29 8 9 27 13 30 15 14 16 12 20 23 24 5 6 25 11 22 21 26 10 18 4 2 3 7 17
Product

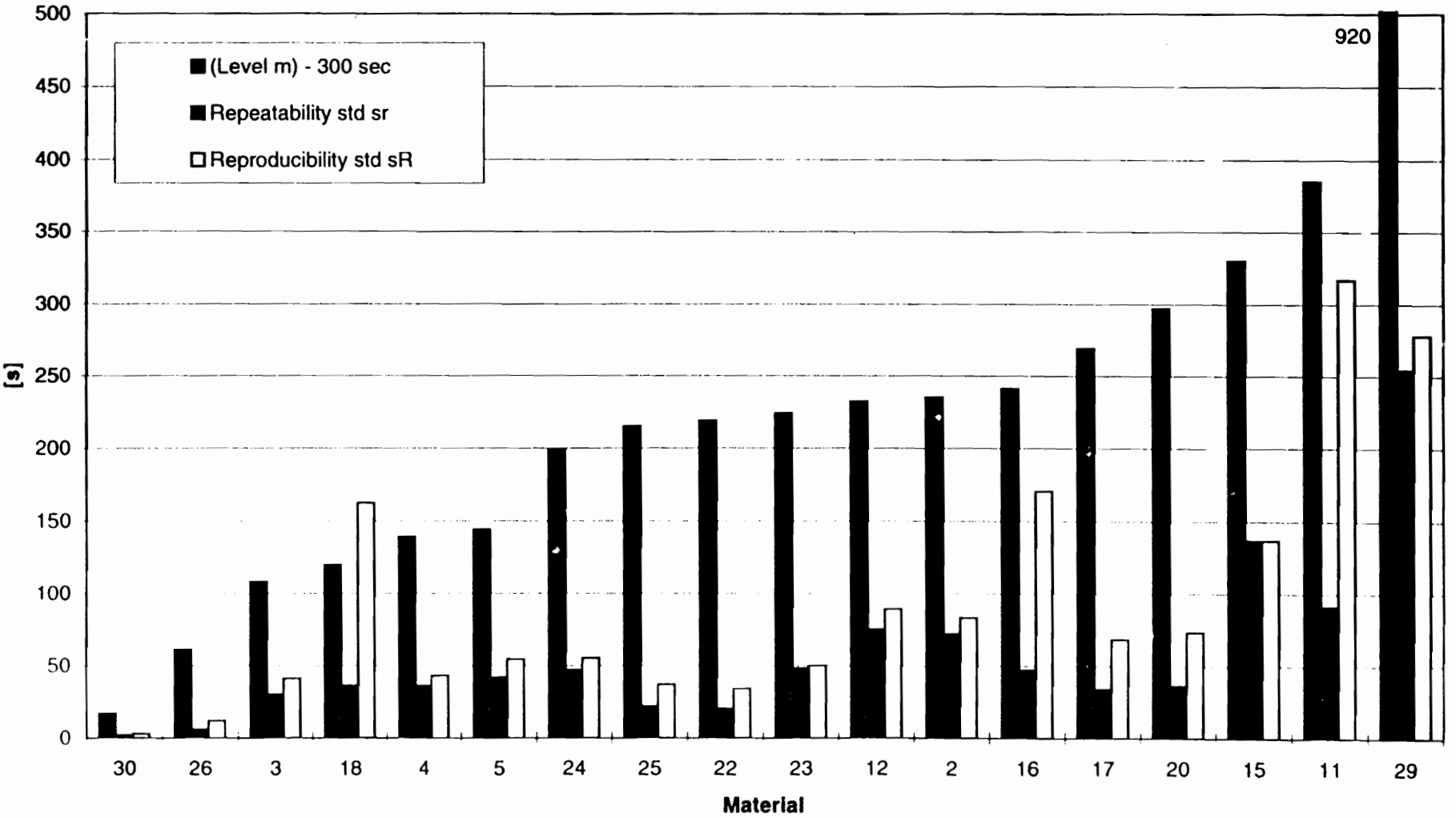

tign vis in s
Level m
Repeatability std sr
Reproducibility std sR
700
600
500
400
300
200
100
0
[s]
30 3 26 18 10 5 4 11 12 17 2 9 24 16 20 29 23 7 1 22 25 8 21 13 15 28 6 14 27 19
Product

tign 5kW in s

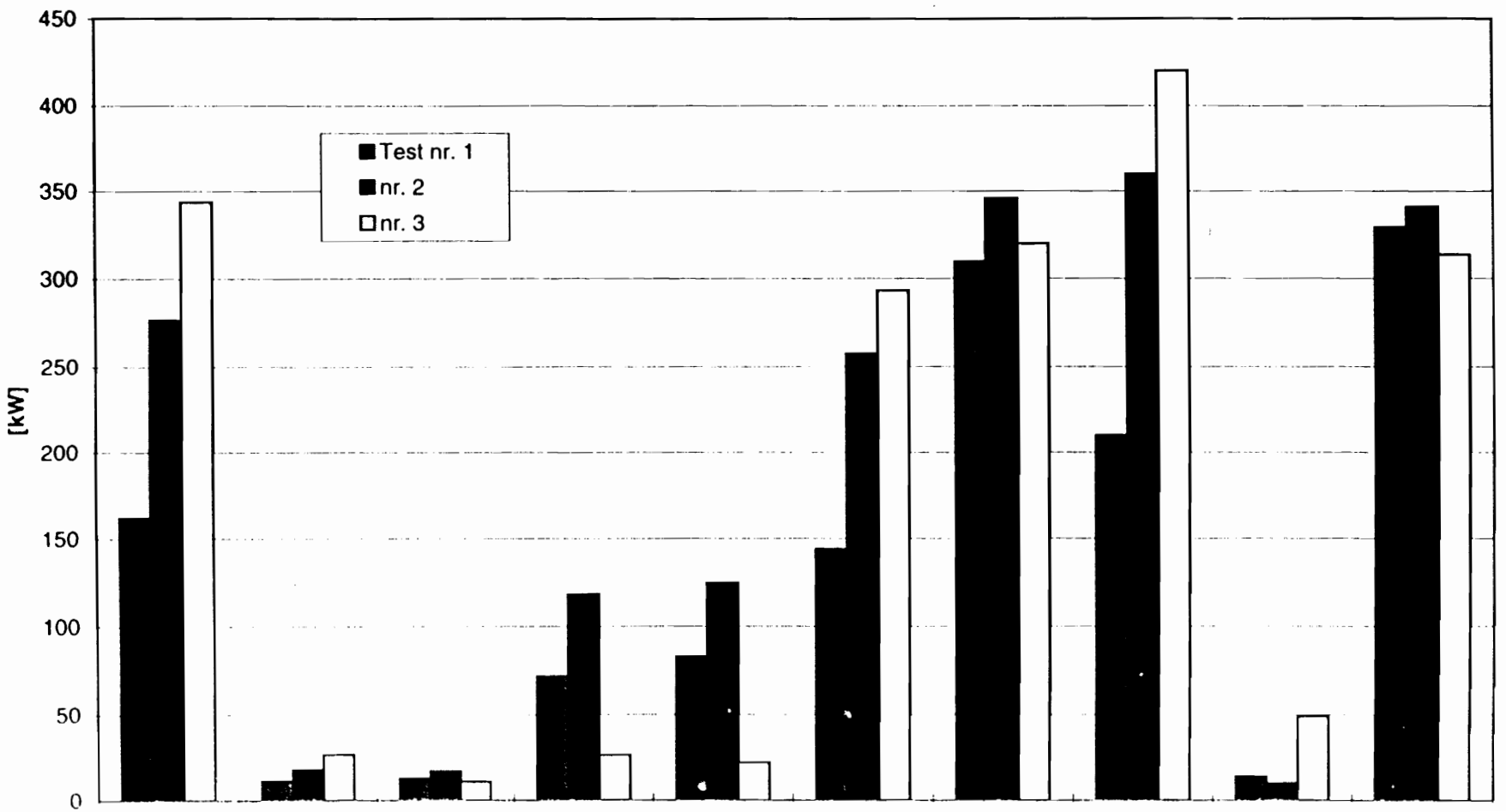

Level m
Repeatability std sr
Reproducibility std sR
[s]
350
300
250
200
150
100
50
0
30 3 26 28 4 5 14 10 12 11 29 24 23 20 18 16 22 2 25 8 1 13 15 27 7 6 17 21 19


tign 3K in s
Level m
Repeatability std sr
Reproducibility std sR
[s]
1200
1000
800
600
400
200
0
30 26 4 5 12 3 10 9 16 29 24 23 20 22 25 18 7 17 2 15 6 21 19 28 11 13 8 27 14 1
Product

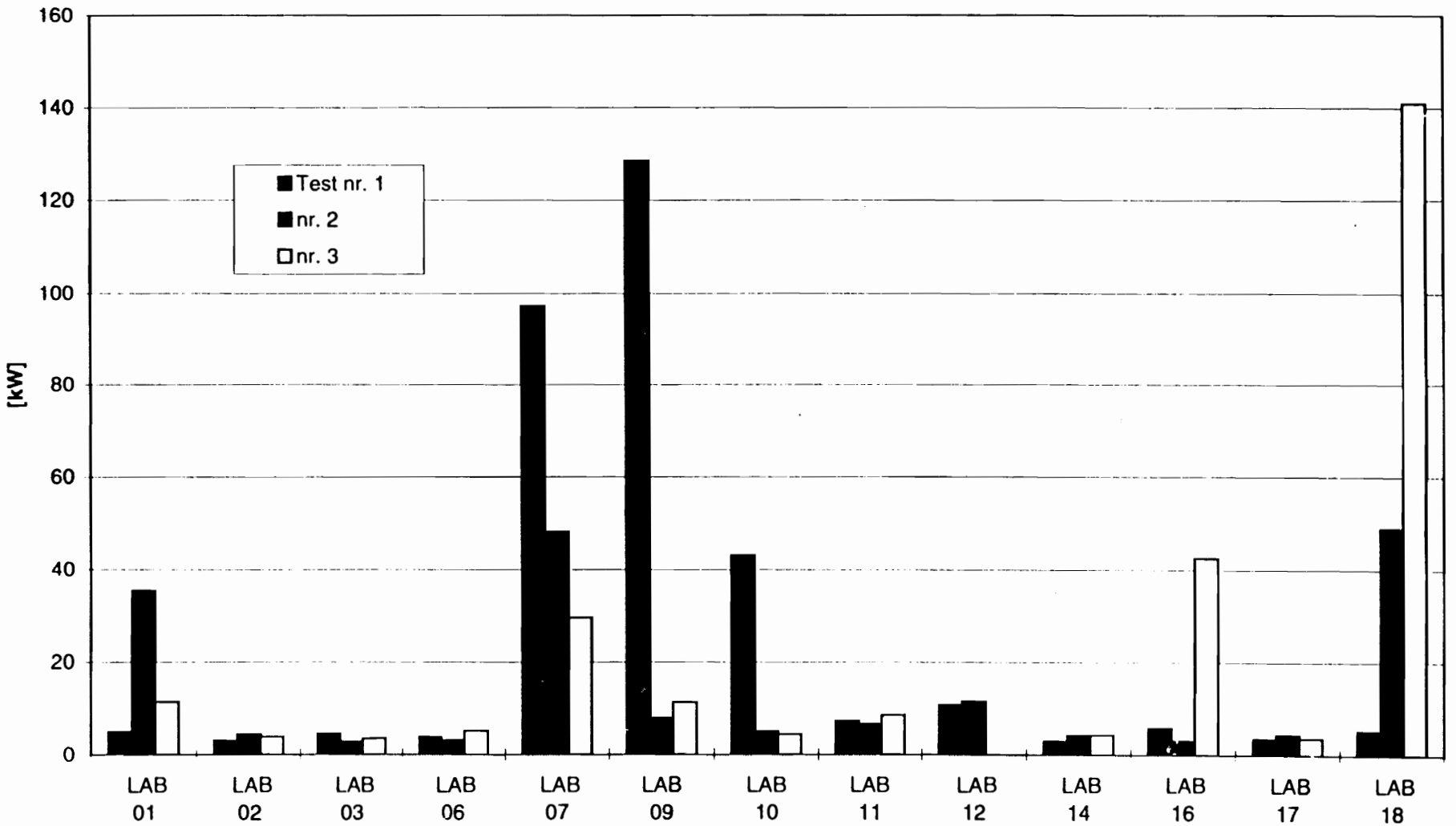
tx 250 in s

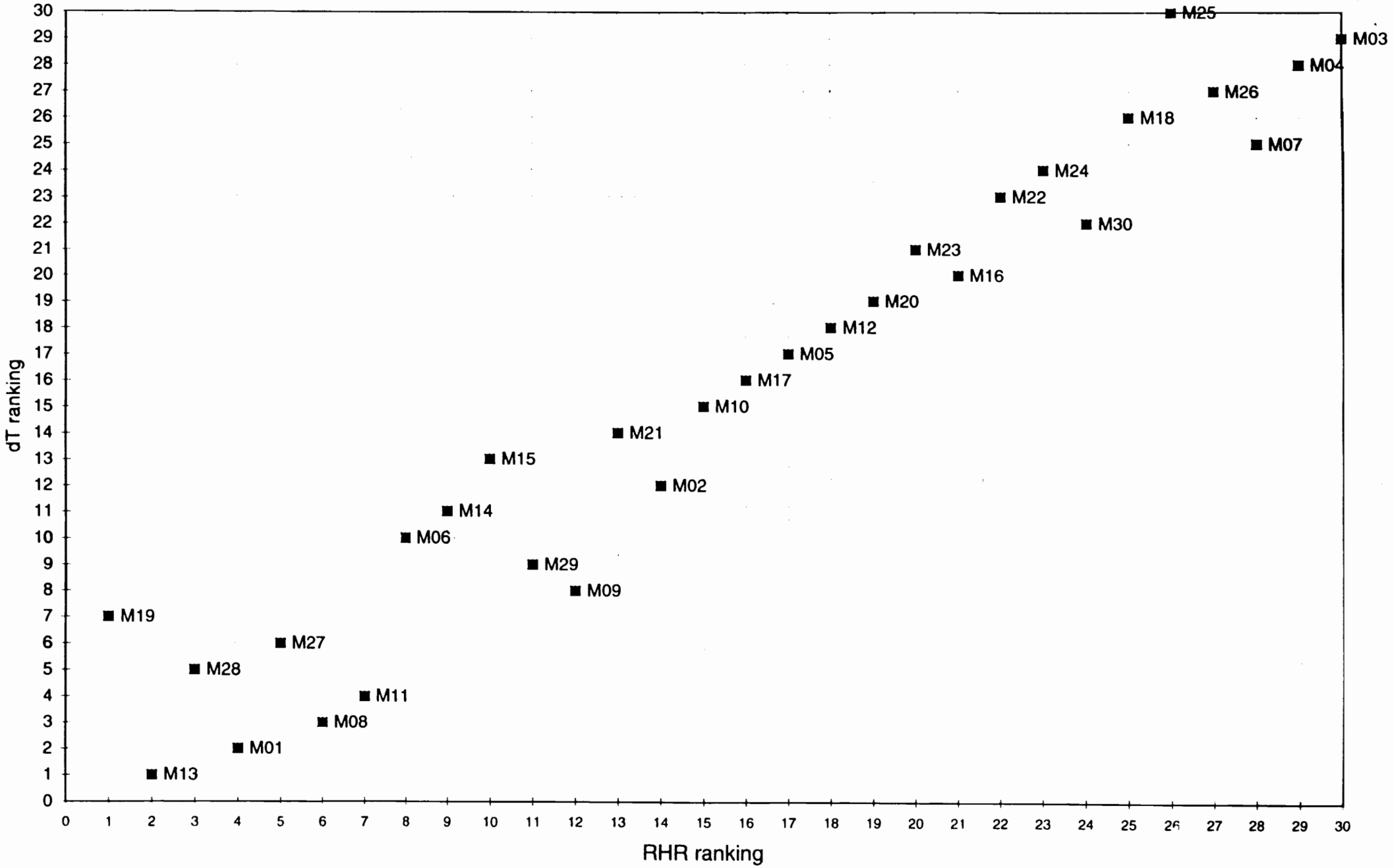

500
450
400
350
300
250
200
150
100
50
0
[s]
(Level m) - 300 sec
Repeatability std sr
Reproducibility std sR
920
30
26
3
18
4
5
24
25
22
23
12
2
16
17
20
15
11
29
Material

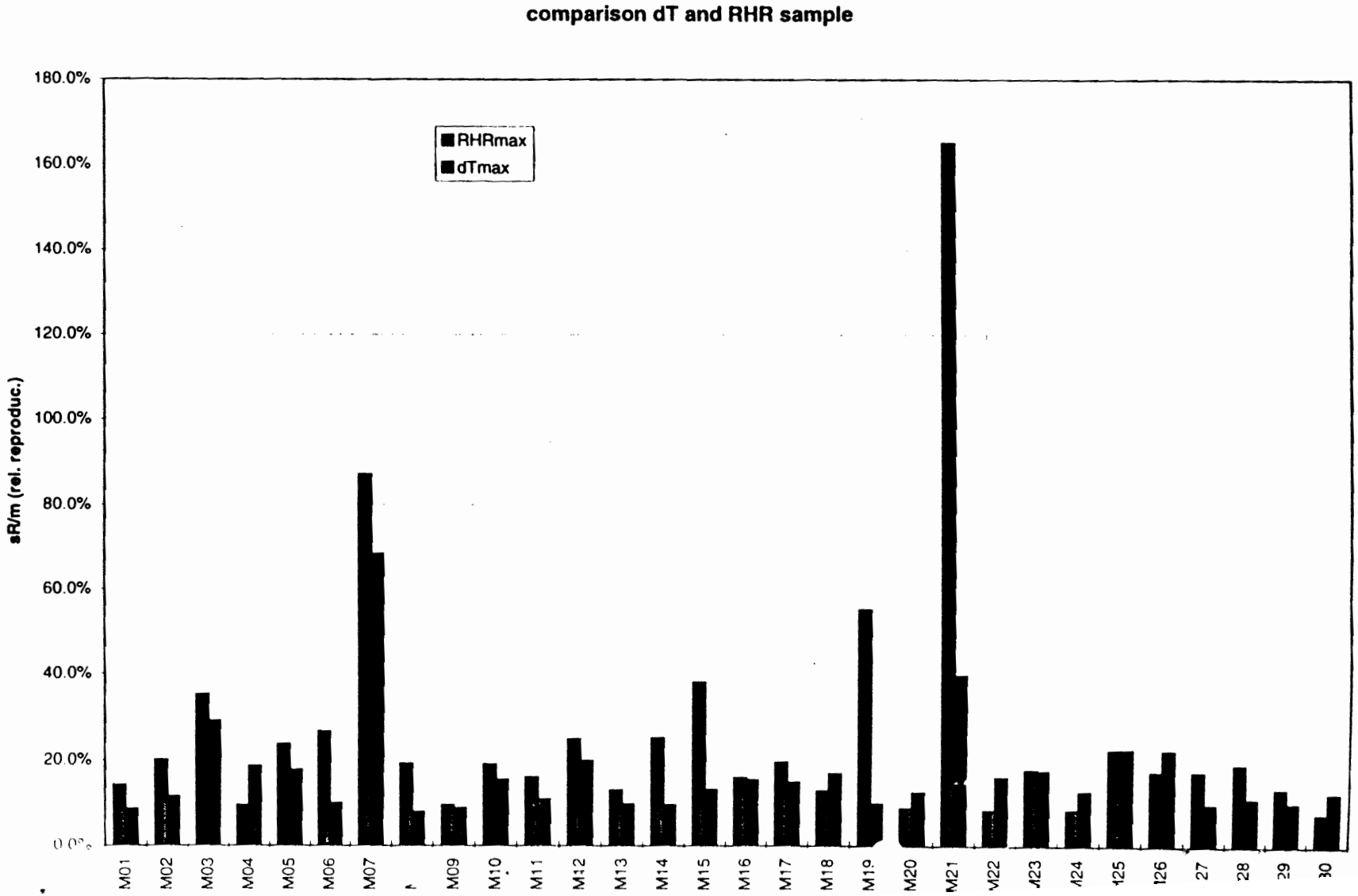
max RHR values from the 3 tests for product 07

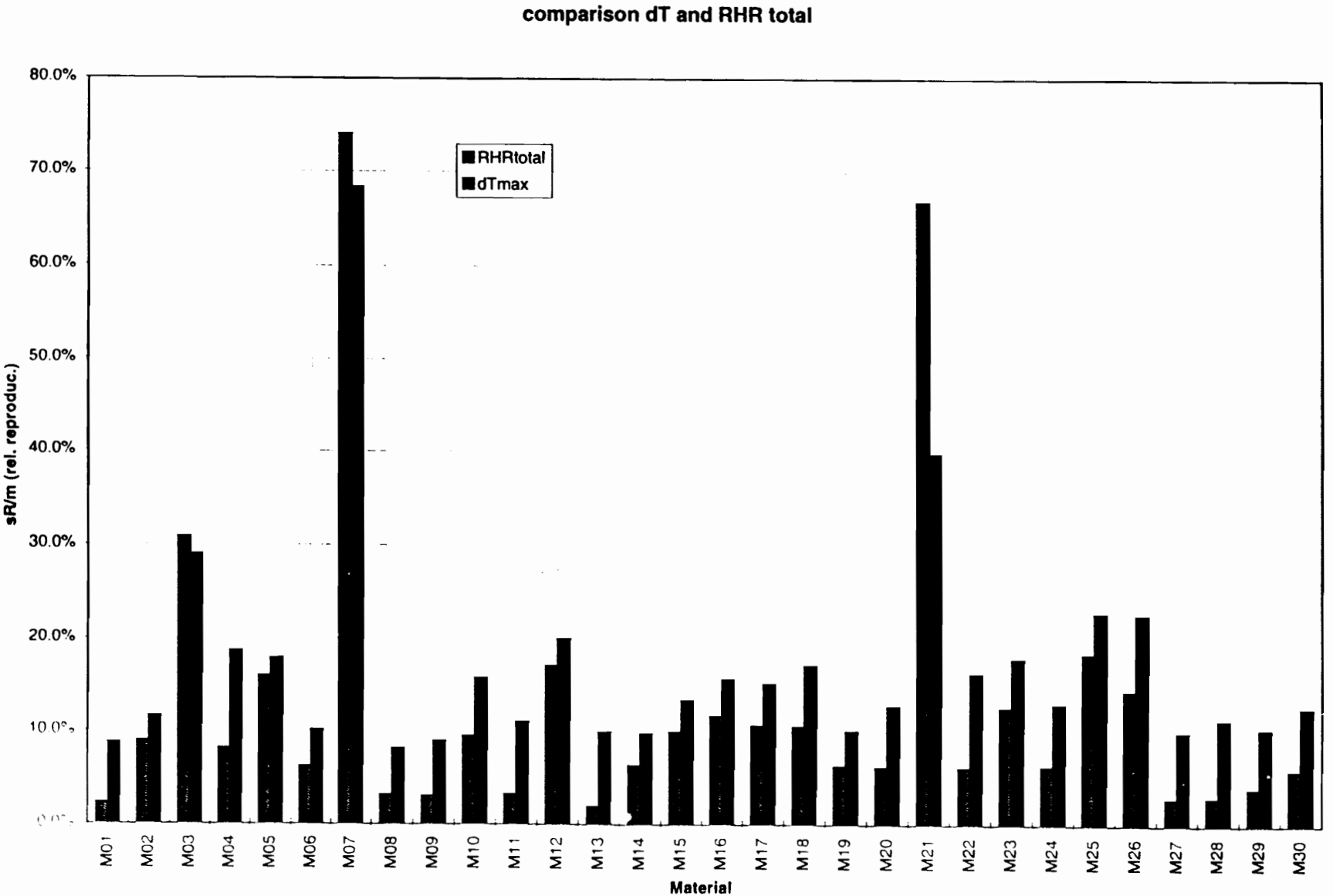


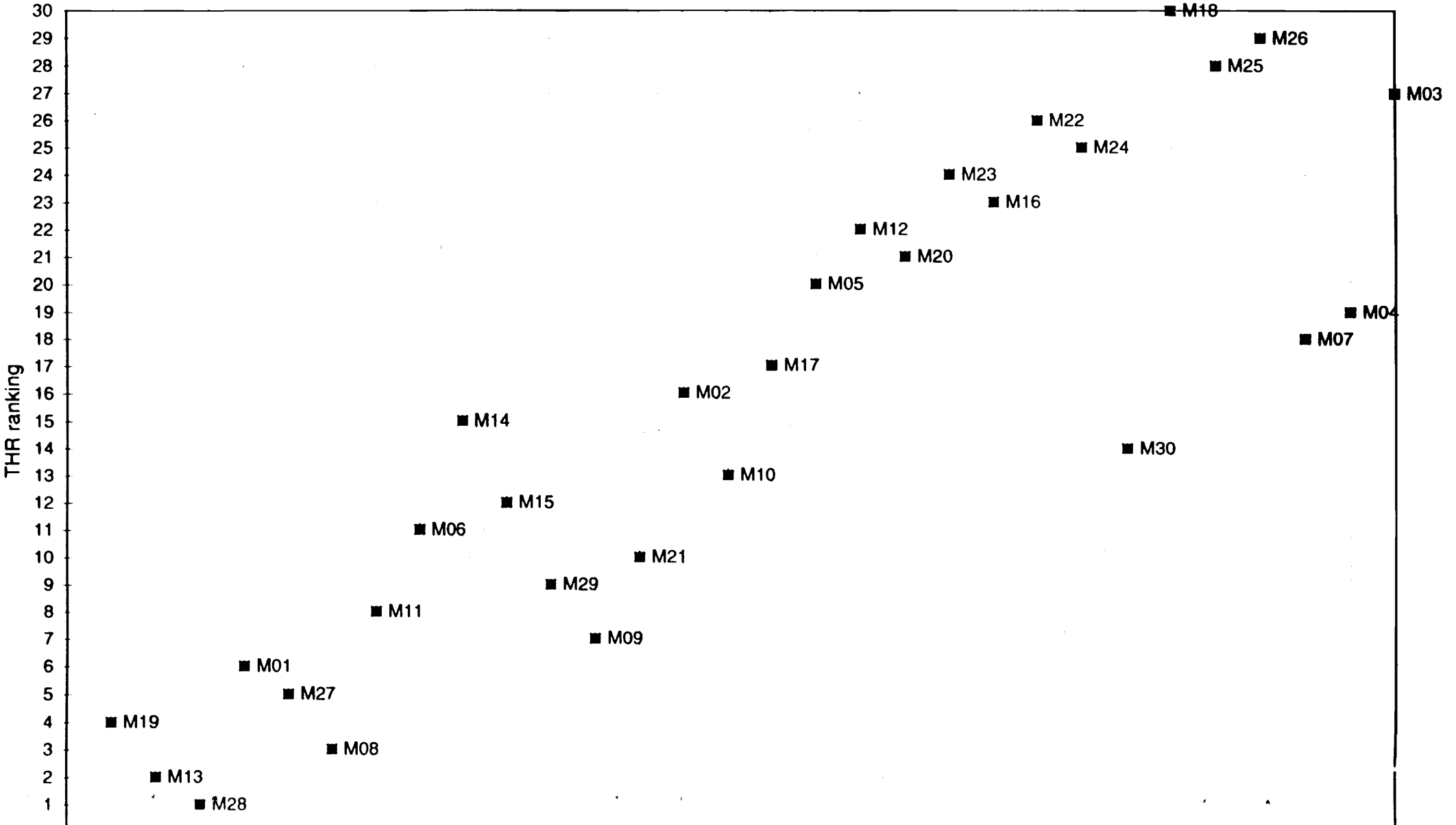
max RHR values from the 3 tests for product 21



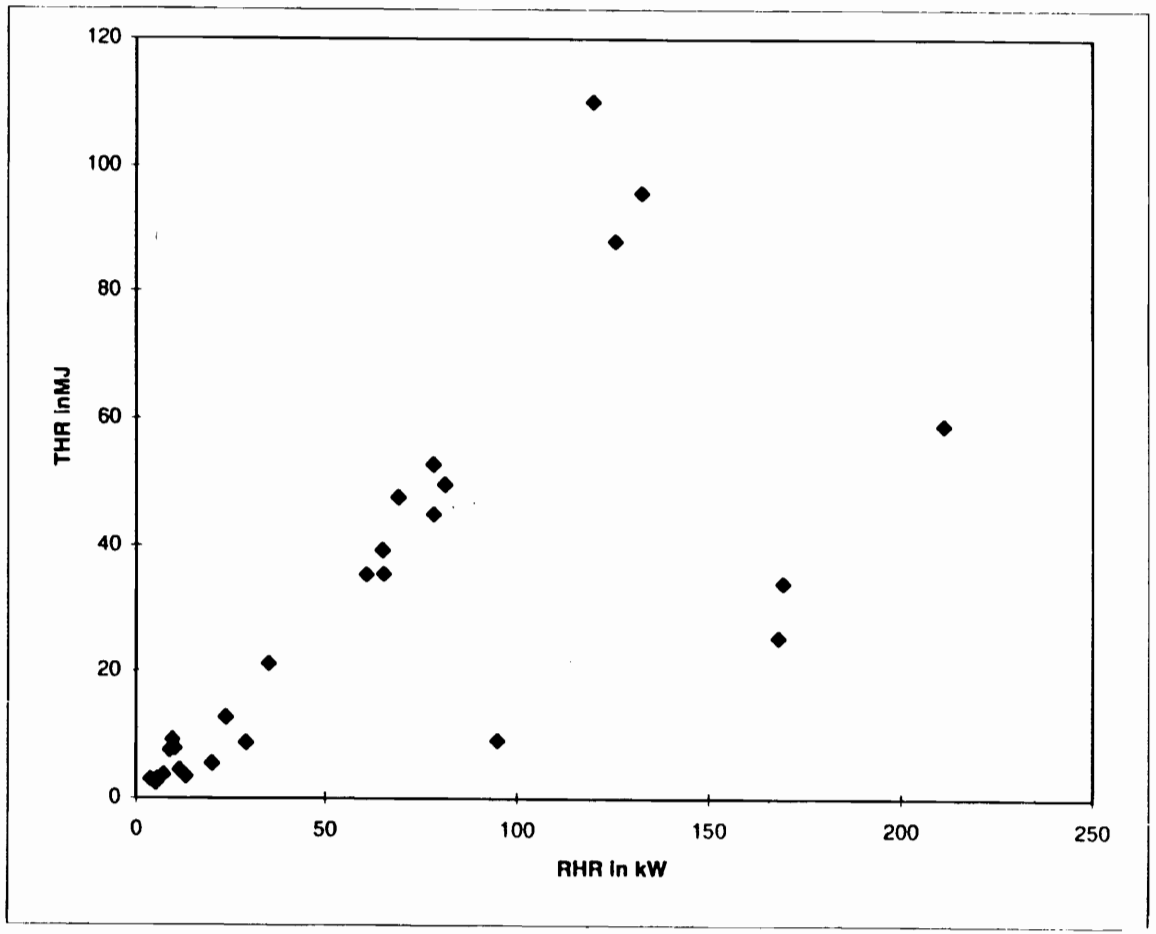

dT ranking
RHR ranking
M25
M03
M04
M26
M18
M07
M24
M22
M30
M23
M16
M20
M12
M05
M17
M10
M21
M15
M02
M14
M06
M29
M09
M19
M27
M28
M11
M08
M01
M13


comparison dT and RHR sample
RHRmax
dTmax
sR/m (rel. reproduc.)
180.0%
160.0%
140.0%
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
M01
M02
M03
M04
M05
M06
M07
M09
M10
M11
M12
M13
M14
M15
M16
M17
M18
M20
M21
M22
M23
M24
M25
M26
27
28
29
30

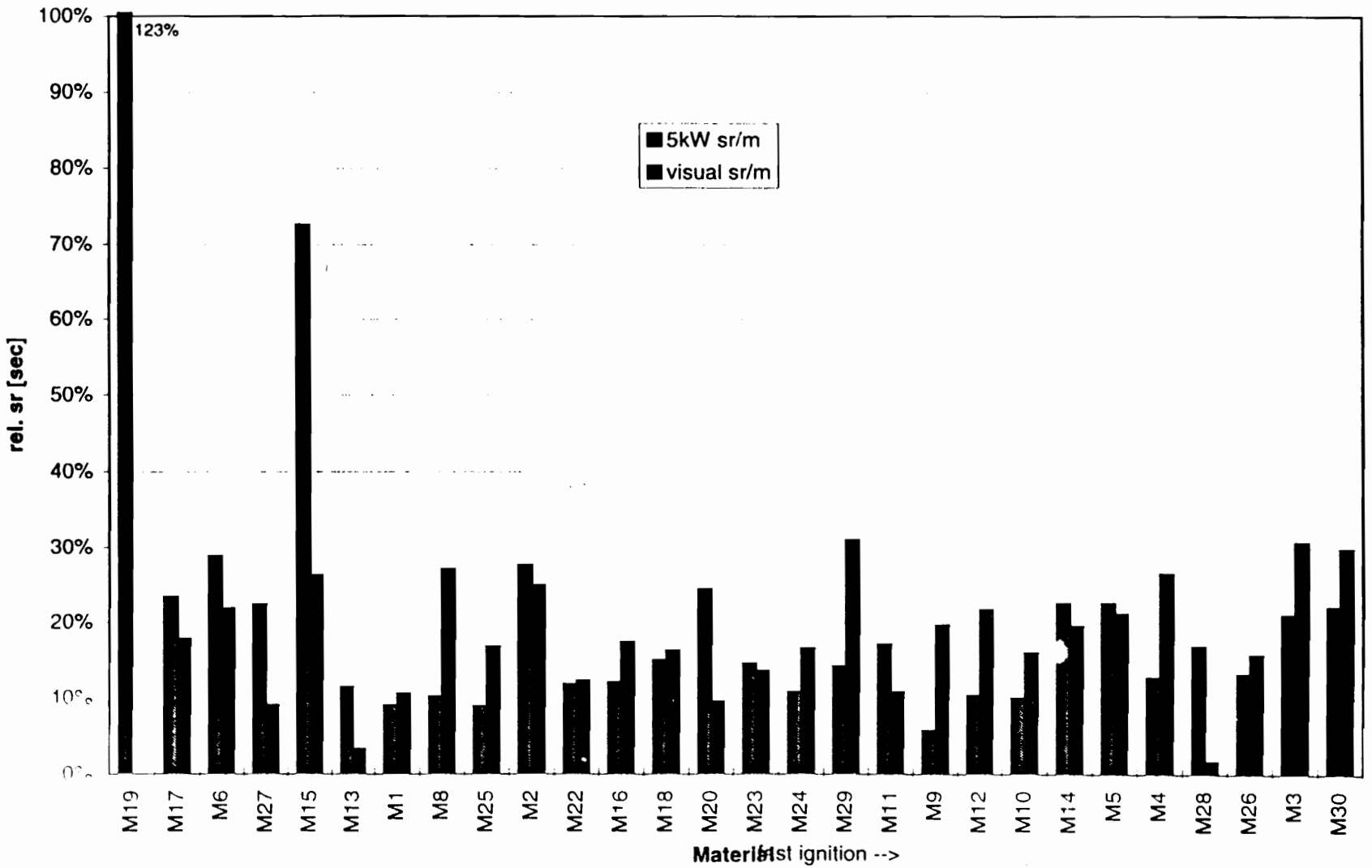

comparison dT and RHR total
RHRtotal
dTmax
sR/m (rel. reproduc.)
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
M01
M02
M03
M04
M05
M06
M07
M08
M09
M10
M11
M12
M13
M14
M15
M16
M17
M18
M19
M20
M21
M22
M23
M24
M25
M26
M27
M28
M29
M30
Material

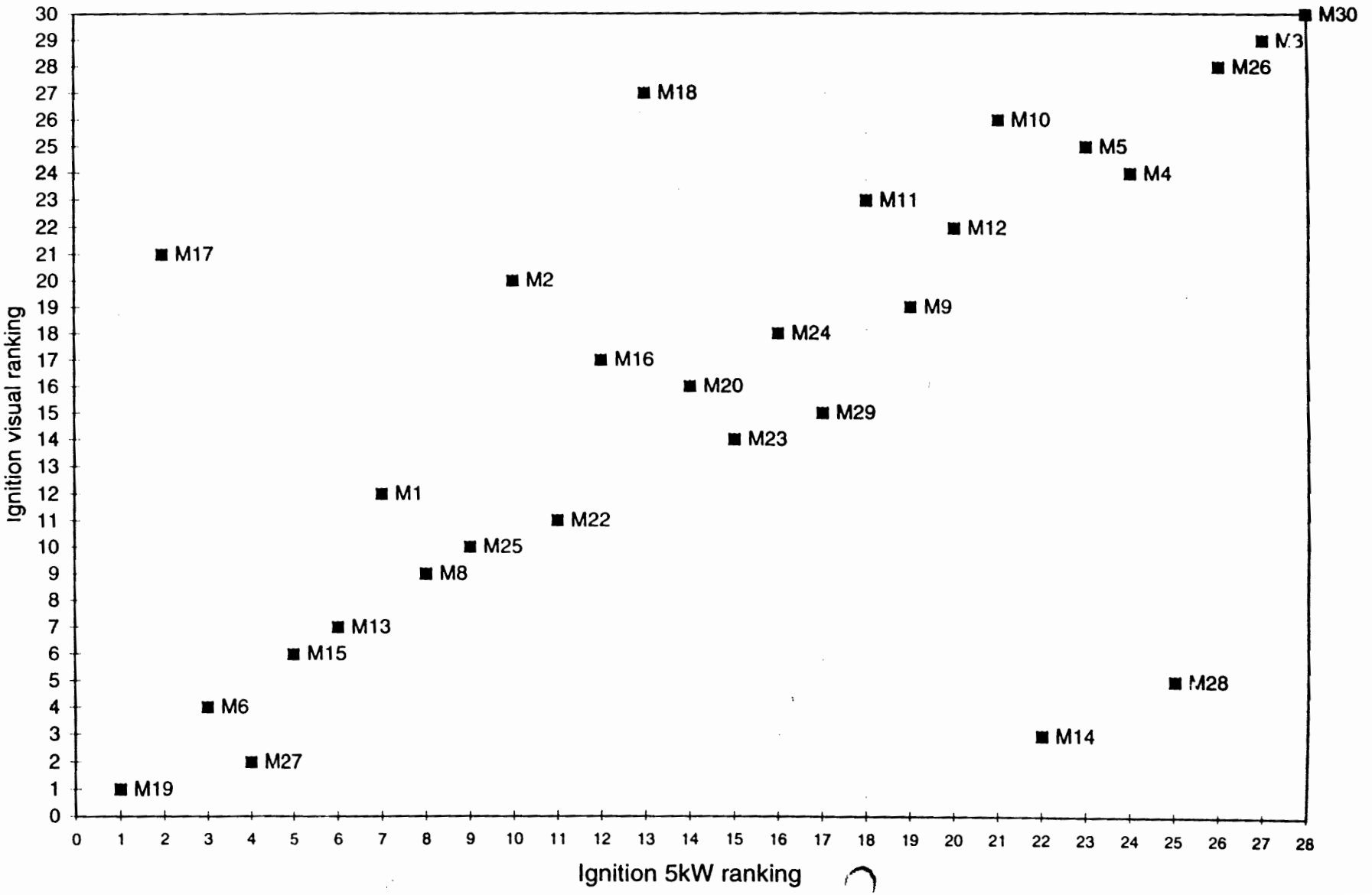

THR ranking
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
M18
M26
M25
M03
M22
M24
M23
M16
M12
M20
M05
M04
M07
M17
M02
M14
M30
M10
M15
M06
M21
M29
M11
M09
M01
M27
M19
M08
M13
M28

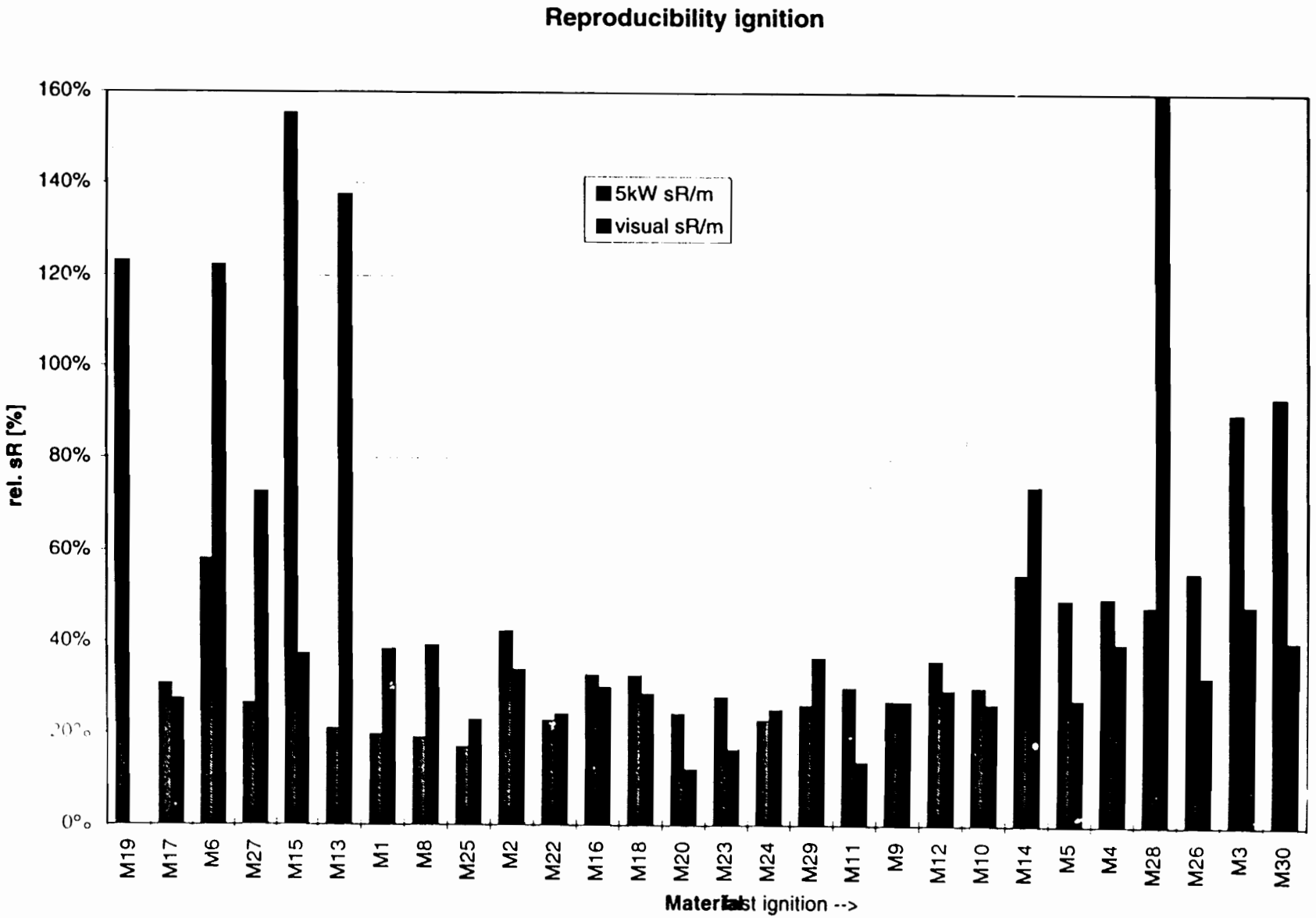
Material no.	RHR	THR
M01	5.6	2.9
M02	23.9	12.6
M03	211.2	58.9
M04	169.2	34.0
M05	60.7	35.3
M06	9.0	7.5
M07	168.0	25.3
M08	5.7	2.7
M09	13.5	3.4
M10	29.3	8.7
M11	7.4	3.6
M12	64.9	39.2
M13	5.0	2.5
M14	9.9	9.1
M15	10.5	7.8
M16	78.2	45.0
M17	35.2	21.1
M18	120.0	110.1
M19	3.8	2.9
M20	65.2	35.4
M21	20.4	5.4
M22	78.2	52.7
M23	69.1	47.6
M24	81.1	49.6
M25	125.9	88.0
M26	132.8	95.8
M27	5.7	2.9
M28	5.2	2.3
M29	11.8	4.4
M30	95.0	9.0

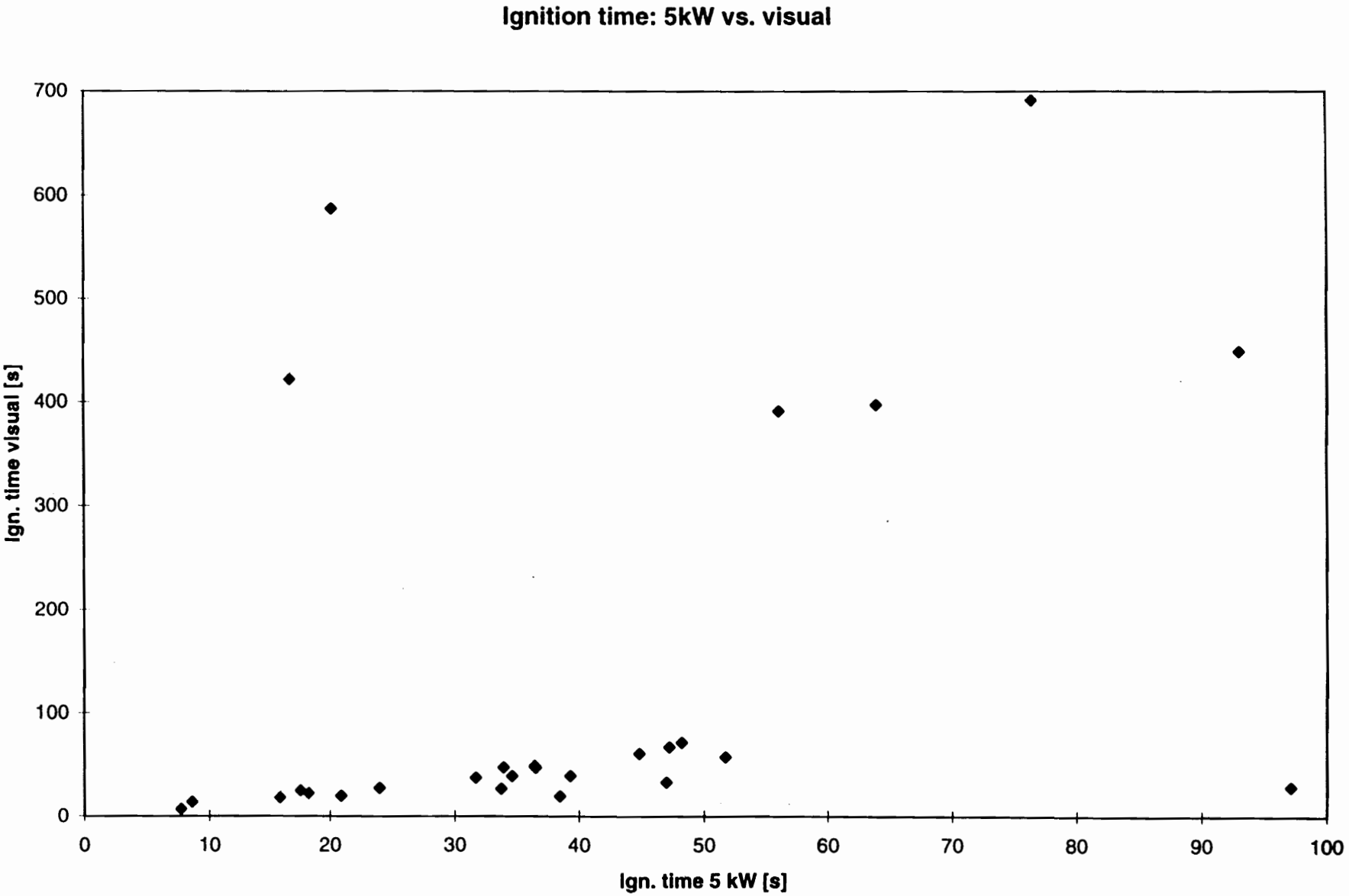


Repeatility ignition




Ignition visual ranking
Ignition 5kW ranking
M30
M3
M26
M18
M10
M5
M4
M11
M12
M17
M2
M9
M24
M16
M20
M29
M23
M1
M22
M25
M8
M13
M15
M28
M6
M14
M27
M19


Reproducibility ignition
160%
140%
120%
100%
80%
60%
40%
0%
rel. sR [%]
5kW sR/m
visual sR/m
M19
M17
M6
M27
M15
M13
M1
M8
M25
M2
M22
M16
M18
M20
M23
M24
M29
M11
M9
M12
M10
M14
M5
M4
M28
M26
M3
M30
Material --> last ignition -->


Ignition time: 5kW vs. visual
Ign. time visual [s]
Ign. time 5 kW [s]
0
100
200
300
400
500
600
700
0
10
20
30
40
50
60
70
80
90
100

Surface spread of flame

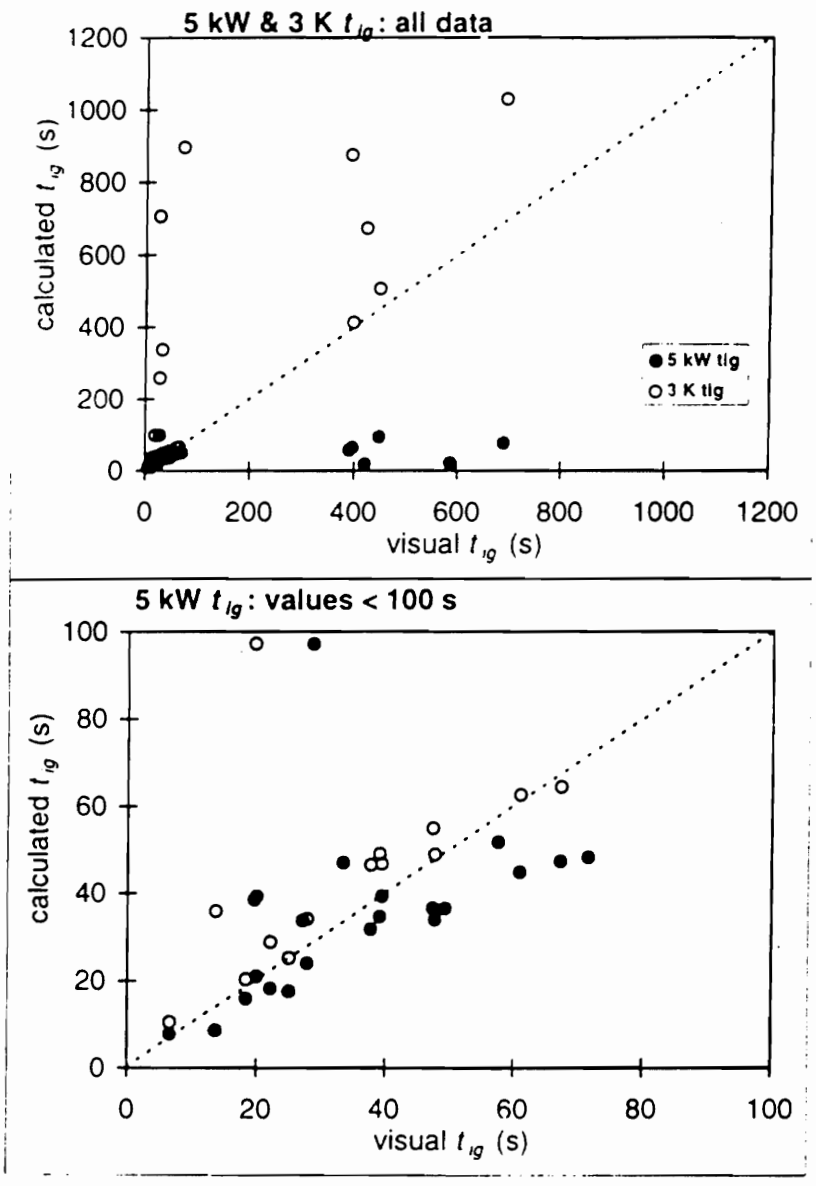
	corner	250	350	450	550	650	750	850	tx250 corrected	sR/m fror tx250 correctec
M01	40									
M08	43									
M13	41									
M14	43									
M19	44									
M27	44									
M28	44									
M09	43	1								
M21	40	1								
M10	37	4								
M15	39	5							330	41.6%
M06	38	5								
M29	34	5							920	30.2%
M07	32	7	1							
M18	22	18							120	.8%
M11	21	23							385	82.4%
M17	19	22	1						269	25.2%
M20	1	38							297	24.5%
M16		37	2						241	70.5%
M04	2	33	2	1					139	31.0%
M02	6	12	14						235	35.3%
M24		29	10						199	27.3%
M23	3	11	21	6					224	22.5%
M22		7	28	1					219	15.4%
M05		2	23	10	2				144	37.9%
M12			19	11	1				232	38.1%
M25			23	18					215	17.0%
M03			3	4	6	2	4	15	8	385.0%
M30							4	38	17	16.8%
M26								41	61	19.5%

Surface spread of flame

	250	350	450	550	650	750	850		tx250 corrected	tx250 rel. reproc. corrected	# in two adjacent regions	# not in two adjacent regions	
M01	40										40		
M08	43										43		
M13	41										41		
M14	43										43		
M19	44										44		
M27	44										44		
M28	44										44		
M09	43	1									44		
M21	40	1									41		
M10	37	4									41		
M15	39	5							330	41.6%	44		
M06	38	5									43		
M29	34	5							920	30.2%	39		
M07	32	7	1								39	1	3%
M18	22	18							120	134.8%	40		
M11	21	23							385	82.4%	44		
M17	19	22	1						269	25.2%	41	1	2%
M20	1	38							297	24.5%	39		
M16		37	2						241	70.5%	39		
M04	2	33	2	1					139	31.0%	35	3	9%
M02	6	12	14						235	35.3%	26	6	23%
M24		29	10						199	27.3%	39		
M23	3	11	21	6					224	22.5%	32	9	28%
M22		7	26	1					219	15.4%	35	1	3%
M05		2	23	10	2				144	37.9%	33	4	12%
M12			19	11	1				232	38.1%	30	1	3%
M25			23	18					215	17.0%	41		
M03			3	4	6	2	4	15	8	385.0%	19	15	79%
M30							4	38	17	16.8%	42		
M26								41	61	19.5%	41		

Flaming droplets/ particles

	Falling of first flaming **droplet/particle** (not considering the 15 sec. burning time)	Falling of first **flow** of droplets/particles
	Number of observations	
M07	35	32
M03	36	25
M17	36	17
M02	35	16
M05	34	10
M12	39	9
M25	35	8
M26	35	8
M23	33	6
M16	33	5
M22	26	5
M21	5	5
M10	29	3
M30	26	3
M29	23	3
M24	30	2
M27	12	2
M04	17	1
M18	15	1
M20	10	1
M11	18	0
M14	13	0
M08	12	0
M09	9	0
M01	6	0
M13	5	0
M06	0	0
M15	0	0
M19	0	0
M28	0	0



Not taken into account:
5 kW: M7, M21 and M19
3 K: M1, M7, M23 and M19

Anhang 2

Kommentierung der Rundversuchsergebnisse

RG N124

RESULTS OF SBI ROUND ROBIN TESTS

OVERVIEW OF THE RESULTS AND RECOMMENDATIONS TO THE EC FIRE REGULATORS

SUMMARY

This document provides some further analysis and comment on the report of the SBI round robin exercise provided by TNO in their report '*Development of the Single Burning Item Test - Results of the SBI Round Robin tests*'.

That report contains much statistical data that was analysed in a short period of time and it would not be unreasonable for additional detailed analysis to lead to improved repeatability and reproducibility, but that is not the objective of this document.

This document compares the results from the statistical analysis given in the above report with data available from other round robin exercises that have been conducted to support ISO test methods involved in the measurement of 'reaction to fire' parameters. Apart from one, these ISO tests are bench scale experiments made on small specimens of the product under very well defined and controlled conditions and it can be expected that the associated levels of repeatability and reproducibility may be the best that can be achieved. The results of this comparison shows that the SBI compares very favourably in terms of repeatability and reproducibility with those test methods for the equivalent parameter, where information is available.

Each of the parameters required for use in the Euroclass system can be measured adequately in the SBI test, although those which rely on subjective observation of the phenomena provide greatest difficulty. It is recommended that the parameter 'heat release' is measured using oxygen depletion calorimetry, and that 'ignition' be defined by a minimum level of heat release.

In common with most fire tests, problems were encountered with the testing of products that exhibit melting, delamination, etc., that tend to influence the spread of results. Similarly, for some products it was not possible within the scale of the test, to provide meaningful fixing details.

This document concludes that, whilst some improvements can still be made to the specification of the method and the engineering of the equipment prior to it being published as a European standard, the method is satisfactory as a basis for providing a mandate to CEN for standardisation.

It is proposed that with some guidance from the EC Fire Regulator's Group on the anticipated use of the various parameters within the Euroclass system, a further analysis of the data may be made, that will indicate the significance of the repeatability and reproducibility of the method to the classification system.

1. INTRODUCTION

The results of the round robin exercise on the Single Burning Item test, including information on each material in terms of repeatability and reproducibility of each of the five parameters used in the Euroclass system, is given in the TNO report ***'Development of the Single Burning Item Test - Results of the SBI Round Robin tests'***, dated October 7, 1997.

That report contains much technical and statistical data that was assembled and analysed in a very short period of time; it contains little detailed investigation and interpretation of the facts. The object of this document is to aid comprehension of the contents of the report.

This document presents a summary of the contents of the report with information to assist in the interpretation of the data. It reviews some of the individual product behaviours in the test and their effect on the repeatability and reproducibility of the method.

In addition this report contains some advice for further improvements and recommendations for future action.

2. STATISTICS

The TNO report considers the repeatability and reproducibility of the SBI test for each of the five parameters referred to in the Euroclass decision. An analysis is made of several aspects of the specific parameter. For example, the 'heat release' is evaluated on the basis of the 'maximum', **RHR**, and 'total', **THR**, values recorded during a test on the basis of oxygen depletion calorimetry. They are also considered on the basis of measurement of temperature increase in the exhaust duct of the combustion gases, ΔT, and on the basis of 'cumulative' temperature increase, **cum.** ΔT, values. These THR and the cum. ΔT values are taken over the whole test duration. The reason for evaluating the different parameters in these different ways is to enable comparisons and the choice of the most appropriate value to use in the classification procedure.

For the different parameters the mean value for all the replicates in all of the laboratories is calculated and is used as the best estimate of the real value of that parameter, this is given as the 'level estimate' ***m***.

The 'repeatability limit' characterises the precision of test results obtained within a single laboratory, and is identified by ***r***. The 'reproducibility limit' quantifies the precision of test results obtained in different laboratories and is identified by ***R***. The tables in the report also give the calculated values of the standard deviation of repeatability and reproducibility S_r and S_R. These values are dependent upon the design parameters of the round robin and the accuracy of these quantities is dependent upon the number of participants in the round robin and the number of replicates. [For this round robin exercise the relationship between the calculated values of S and the statistically relevant value of the true population standard deviation σ (which is unknown) is given by a relationship of $(S - \sigma)/\sigma$, which equals 28%.].

An absolute measure of the value of repeatability and reproducibility, independent of the number of participating labs and replicates, is given by the r and R values given in the tables, corresponding with a 95% probability. The repeatability, r, is the value below which the difference between any two measured values of a particular parameter in the test may be expected to lie, when measured within any single laboratory (with a 95% probability). The reproducibility, R, is the value below which the difference between any two measured values of a particular parameter in the test may be expected to lie, when measured in different laboratories (with a 95% probability).

Clearly, for a small absolute value of any parameter, repeatability and reproducibility will be large when expressed as relative values (*r/m* or *R/m* in %). In addition to the mathematical distortion, as values approach zero instruments come close to their limit of sensitivity and provide less repeatable values. However, such low values are of little significance in the overall scheme of a classification system.

A visual presentation of the results of the analysis, providing an easy comparison, is given in the histograms in Annex 5. In these graphs it is most illustrative to look at the relationship between the level *m* value and the associated repeatability standard deviation s_r and the associated reproducibility standard deviation s_R. The values of s_r and s_R should be small in comparison to the value of level *m* value.

In the analysis frequent reference is made to 'stragglers' and 'outliers'. These are entries that are deemed to have a low probability of occurrence with 'stragglers' identified as values with a probability of occurrence of less than 5% and 'outliers' being those stragglers whose probability of occurrence of less than 1%. Only 'outliers' are excluded from the analysis. Their identification is on the basis of statistical tests conducted in accordance with ISO 5725. Where values are clearly spurious, they may be dismissed from the analysis on the basis of pre-test evaluation. Normally, the reason for the erroneous data will be resolved before the numerical analysis, but in this exercise there was both insufficient material for a laboratory to repeat any defective test and insufficient time for the consultation to take place with the laboratory. Therefore, in some cases data may have been excluded from the analysis either because they were missing or where they clearly have no physical meaning, e.g. negative values of heat release or smoke, or values of infinity. No data has been excluded from the analysis because of inconsistent or abnormal results.

The repeatability and reproducibility of any test method includes components associated with the test method and components associated with the product that is the subject of evaluation during that test. An examination of the data illustrates that the relatively large values for repeatability and reproducibility are associated with products that exhibit some form of mechanical or thermal influences during the test, and this can be supported by the visual observations of the performances of these products recorded by the laboratories.

The results of the analysis relate to the full test duration of 20 minutes that was arbitrarily chosen in order to ensure that no behavioural aspects were excluded. For the purpose of application of the test within a classification system, the test data obtained during the early test period are expected to be more relevant. An evaluation over a shorter duration of test as well as a more critical evaluation conducted around the limit values set for classification limits will greatly improve the results of the analysis. An examination of the raw data for many materials illustrates that the greatest variability in RHR and rate of smoke production occurs in the later stages of the test, after the achievement of maximum values for RHR and cum.ΔT.

Compared with the behaviour of products in other types of test that determine more physically based parameters, fire tests are known to have a relatively poor level of repeatability and reproducibility. This is mainly a function of the natural variability associated with the fire phenomena.

To provide a basis for judgement of the results of the analysis, therefore, it is of particular value to look at the results from other round robin exercises on other fire tests. A number of such exercises have been conducted on tests that have been the subject of international development, and for which repeatability and reproducibility values are available.

ISO 5657 (1997)

PARAMETER	Mean value	Mean r	Mean R	Mean S_r/m	Mean S_R/m
Time to ignition at 40kW/m^2 (sec)	20.5 - 58	4.4 - 8.8	6.0 - 19.4	3.5 - 7.6%	6.5 - 12%
Time to ignition at 30kW/ m^2 (sec)	30 - 138	6.2 - 51	8.1 - 75	3.3 - 13%	7.6 - 19%

ISO 5658

PARAMETER	Mean value	Mean r	Mean R	Mean S_r/m	Mean S_R/m
Heat of sustained burning (MJ/m^2)	2.0 - 11.2	0.19 - 4.57	0.45 - 8.53	3.4 - 15%	8.0 - 27%
Critical flux at extinguishment (kW/m^2)	3.4 - 35	2.2 - 12.3	3.6 - 15.5	3.3 - 34%	12 - 38%

ISO 5660

PARAMETER	Mean value	Mean r	Mean R	Mean S_r/m	Mean S_R/m
Time to ignition (sec)	5 - 150	4.7 - 23	8.5 - 40	34% - 5.4%	61%- 9.6%
Max RHR (kW/ m^2)	70 - 1120	22.5 - 160	70 - 218	11.5% - 5.1%	35.9% - 7.0%
Total heat release (MJ/m^2)	5 - 720	7.7 - 56	12.2 -75	55% - 2.8%	87% - 3.7%

ISO 9705/ASTM

PARAMETER	Mean value	Mean r	Mean R	Mean S_r/m	Mean S_R/m
Max RHR (kW/ m^2)	187 - 436	23 - 493	54 - 493	4.4 - 47.5%	10.4 - 47.5%
Total heat release (MJ/m^2)	103 - 163	14 - 79	35 - 83	3.6 - 17.1%	12.1 - 20.7%
Max RSP (m^2/s)	0.48 - 2.0	0.06 - 9.2	0.86 - 9.2	3.6 - 76.9%	51.4 - 83.9%
Total smoke (m^2)	178 - 693	29 - 405	219 - 535	5.7 - 37.1	25.0 - 58.9

Note: **The data from the ISO/ASTM round robin given here are not very statistically significant since they relate in some cases to results from only 3 or 4 laboratories and 5 materials. Whilst the parameters are comparable with those evaluated in the SBI, they are not necessarily relevant to the use of the data.**

Whilst the repeatability and reproducibility will be dependent upon the parameter being measured as well as the (limit) value of the criterion, these results provide some background against which to judge the performance of the SBI.

3. RESULTS OF THE SBI TEST

3.1 Material and parameter analysis

Two materials proved to be troublesome during the test because of their behaviour as a consequence of the inability to provide realistic mountings or fixings. These were the

'polycarbonate panel' (M07), and the 'eps sandwich panel' (M21). As a consequence, these materials may be difficult to test reliably in the SBI and should be referred to the reference scenario for evaluating their fire performance characteristics. Other than these materials, there were few problems with testing the remainder of the 28 materials.

This section summarises the results of the SBI round robin analysis. It indicates the range of the parameter measured by giving the minimum and maximum results. It provides observation on some of the results:

3.1.1 Heat release

The range of values of maximum rate of heat release and the equivalent total heat release, given by oxygen depletion calorimetry and indicated by ΔT, provided from the total range of materials tested, and the associated repeatability and reproducibility, were as follows:

i) Rate of heat release

The maximum rate of heat release measured by oxygen depletion calorimetry from any material during the exercise was for the 'extruded polystyrene board' and the minimum was for the 'unfaced rockwool'.

	RHR	r	R	S_r/m	S_R/m
xps board	**211kW**	**85.2kW**	**210kW**	**14.3%**	**35.1%**
rockwool	**3.8kW**	**2.6kW**	**5.8kW**	**24.4%**	**53.7%**

The extruded polystyrene board exhibited variable melting/softening phenomena in the test and its RHR, therefore, depended on how any specimen of the material reacted during the test. Excluding this material for that reason, the next highest RHR was for the 'PUR foam panel' which provides the following data.

pur foam	**169.2kW**	**45.5kW**	**45.5kW**	**9.5%**	**9.5%**

The results from the rockwool material are probably at the level of minimum resolution of the test method (say 5 kW), and is a material that would be unlikely to be the subject of classification by this test. Looking at the next to the lowest heat release material, above the rockwool, we find the 'gypsum plasterboard on polystyrene' material provides the following data.

gypsum/eps	**5.0kW**	**1.67kW**	**1.86kW**	**11.8%**	**13.1%**

Excluding the two problem materials listed above and the eps and the rockwool material (for the reasons given) provides for a variation of S_r/m from 4.7% to 27.3% with a mean value of 12.5%, and a variation of S_R/m from 7.6% to 37.5% with a mean value of 16.5%.

The equivalent ranges of values of S_r/m and S_R/m for this parameter measured in the round robin exercise for the 'cone calorimeter', which represents a bench scale more accurate measure of the value for a 'material' rather than a 'product' in end use application, were 5.1 - 11.5% and 7.0 - 35.9% respectively. The equivalent values for the 'ISO room' were 4.4 - 47.5% and 10.4 - 47.5%.

The test is, therefore, capable of measuring both high and low rate of heat releases by the use of oxygen calorimetry with good repeatability and reproducibility.

ii) Total heat release

The maximum total heat release measured by oxygen depletion calorimetry from any material during the exercise was for the 'PVC covered electric cables' and the minimum was for the 'acoustic mineral fibre tiles'.

	THR	r	R	S_r/m	S_R/m
PVC cables	**101.1MJ**	**16.3MJ**	**38.7MJ**	**5.2%**	**12.4%**
min fibre tile	**2.3MJ**	**2.0MJ**	**2.8MJ**	**30.6%**	**42.8%**

This measurement of this parameter provides a variation of S_r/m from 5.2% to 40.7% with a mean value of 16.8%, and a variation of S_R/m from 6.8% to 59.9% with a mean value of 25.5%.

The equivalent ranges of values of S_r/m and S_R/m for this parameter measured in the round robin exercise for the 'cone calorimeter' were 2.8 - 55% and 3.7 - 87% respectively. The equivalent values for the 'ISO room' were 3.6 - 17.1% and 12.1 - 20.7%.

The test is, therefore, capable of measuring both high and low total heat releases by the use of oxygen calorimetry with good repeatability and reproducibility.

iii) Maximum ΔT

The maximum heat release indicated by the increase in temperature rise of the gases from inlet to outlet of the test configuration for any material during the exercise was for the 'medium density fibreboard' and the minimum was for the 'gypsum plasterboard on polystyrene'.

	ΔT	r	R	S_r/m	S_R/m
med f/board	**202.2K**	**59.1K**	**130.7K**	**10.3%**	**22.8%**
gypsum/esp	**31.0K**	**1.8K**	**8.7K**	**2.0%**	**9.9%**

The measurement of this parameter provides a variation of S_r/m from 1.6% to 15.5% with a mean value of 6.4%, and a variation of S_R/m from 8.1% to 29.0% with a mean value of 14.3%.

The test is, therefore, capable of indicating both high and low rate of heat releases by temperature differential with good repeatability and reproducibility.

iv) Cumulative ΔT

The maximum total heat release indicated by the integrated temperature rise of the gases from inlet to outlet of the test configuration for any material during the exercise was for the 'medium density fibreboard' and the minimum was for the 'gypsum plasterboard'.

	cum. ΔT	r	R	S_r/m	S_R/m
med f/board	**144063Ks**	**18164Ks**	**62406Ks**	**4.5%**	**15.3%**
gypsum p/b	**35131Ks**	**2443Ks**	**8932Ks**	**2.5%**	**9.0%**

The measurement of this parameter provides a variation of S_r/m from 1.6% to 13.4% with a mean value of 4.1%, and a variation of S_R/m from 8.2% to 18.6% with a mean value of 12.2%.

The test is, therefore, able to provide an indication of total heat release using the cum. ΔT value, with good repeatability and reproducibility.

3.1.2 Smoke production

The smoke production from the tested product was measured by a light source and photo-cell arrangement within the exhaust duct of the equipment. The range of values for the maximum rate of smoke production, and the total smoke production provided from the total range of materials tested, and the associated repeatability and reproducibility, were as follows:

i) **Rate of smoke production**

	RSP	r	R	S_r/m	S_R/m
acoustic tile	**0.119m^2/s**	**0.053 m^2/s**	**0.124 m^2/s**	**15.6%**	**36.6%**
pvc pipes	**5.21 m^2/s**	**1.60 m^2/s**	**3.80 m^2/s**	**10.8%**	**25.8%**

The measurement of this parameter provides a variation of S_r/m from 6.6% to 72.9% with a mean value of 20.7%, and a variation of S_R/m from 18.9% to 114.2% with a mean value of 51.2%.

The equivalent ranges of values of S_r/m and S_R/m for this parameter measured in the round robin exercise for the 'ISO room' were 3.6 - 76.9% and 51.4 - 83.9% respectively.

The test indicates a reasonable level of repeatability in measuring this parameter, but the reproducibility is not good. However, the values obtained are comparable with those given from the ISO room test.

ii) **Total smoke production**

	TSP	r	R	S_r/m	S_R/m
pvc pipes	**2735 m^2**	**624 m^2**	**2149 m^2**	**8.1%**	**27.8%**
painted p/b	**99.2 m^2**	**40.8 m^2**	**118.6 m^2**	**14.5%**	**42.3%**

The measurement of this parameter provides a variation of S_r/m from 8.1% to 78.4% with a mean value of 22.4%, and a variation of S_R/m from 23.0% to 87.8% with a mean value of 53.4%.

The equivalent ranges of values of S_r/m and S_R/m for this parameter measured in the 'ISO room' were 5.7 - 37.1% and 25.0 - 58.9%.

Comparable information, but not directly equivalent, is available from work in ISO on the use of the 'cone calorimeter' for smoke measurement. These are given in the report and provide, from the limited range of materials tested, values of S_r/m of approximately 6% to 60% and values of S_R/m of approximately 16% to 100%. It is interesting to note that the lowest values are associated with the very high smoke producing products, and the higher values with the very low smoke producers.

The test indicates a reasonable level of repeatability in measuring this parameter, but the reproducibility is not good. However, the values obtained are slightly worse than those given from the ISO room test, but are comparable with those for the ISO cone calorimeter.

3.1.3 Ignition

The test evaluates the time to ignition using visual observation of time to ignition as well as time to 5kW rate of heat release and time to a temperature rise of 3K. The range of values for each method of evaluation provided from the total range of materials tested, and the associated repeatability and reproducibility, were as follows:

i) Visual

	tign (visual)	r	R	S_r/m	S_R/m
gypsum/pur	691.2 sec	176.7 sec	1419.5 sec	9.0%	72.6%
paper/glasswool	6.7 sec	5.6 sec	7.8 sec	29.5%	41.1%

The measurement of this parameter provides a variation of S_r/m from 1.7% to 68.9% with a mean value of 19.6%, and a variation of S_R/m from 12.1% to 159.8% with a mean value of 29.9%.

Visual observations of ignition are made both in the ISO ignitability test, ISO5657, and in the cone calorimeter, ISO5660. In ISO5657 the value of S_r/m varies from 3.3% to 13%, and S_R/m varies from 6.5% to 19%, both dependent upon the heat flux level. In ISO5660 the value of S_r/m varies from 5.4% to 34%, and S_R/m varies from 9.6% to 61%.

By comparison the test does not provide for good repeatability and reproducibility of time to ignition on the basis of visual observation of the time to ignition.

ii) 5kW threshold

	tign 5kW	r	R	S_r/m	S_R/m
rockwool	279.3 sec	972.4 sec	972.4 sec	123.1%	123.1%
paper/glasswool	7.7 sec	4.9 sec	20.3 sec	13.0%	35.4%

The measurement of this parameter provides a variation of S_r/m from 5.7% to 123.1% with a mean value of 17.7%, and a variation of S_R/m from 17.0% to 155.3% with a mean value of 42.6%.

Many of the products that provide a high repeatability and reproducibility are very low rate of heat release products, close to the suggested minimum resolution for the equipment and, therefore, the measurement will be inherently variable for those products.

The test provides a slightly worse repeatability and reproducibility on the basis of judging the time to ignition on a rate of heat release of 5kW, than on the basis of visual observation.

iii) $\Delta T = 3K$

	tign 3K	r	R	S_r/m	S_R/m
gypsum/pur	1029.3 sec	247.8 sec	388.0 sec	8.5%	13.3%
paper/glasswool	10.4 sec	3.8 sec	10.4 sec	13.0%	35.4%

The measurement of this parameter provides a variation of S_r/m from 6.4% to 37.3% with a mean value of 11.8%, and a variation of S_R/m from 9.2% to 80.2% with a mean value of 22.3%.

The test provides a good repeatability and reproducibility for measurement of time to ignition on the basis of a 3K temperature increase.

3.1.4 Flame spread

The measurement of flame spread in the test is based on visual observation of the time for the flame to travel laterally to distances of 250mm and to subsequent 100mm intervals. Vertical flame spread is based on visual observation of the time for flame to reach the top edge of the specimen.

Excluding the two problem materials listed above provides:

For vertical flame spread: a variation of S_r/m from 6.9% to 40.8% with a mean value of 18.2%, and a variation of S_R/m from 13.3% to 131% with a mean value of 51.4%.

For t_{x250} flame spread a variation of S_r/m from 9.2% to 41.5% with a mean value of 22.1%, and a variation of S_R/m from 15.5% to 135% with a mean value of 39.3%.

For t_{x350} flame spread a variation of S_r/m from 7.1% to 28.7% with a mean value of 18.9%, and a variation of S_R/m from 15.7% to 74.9% with a mean value of 35.2%.

Comparison of the flame spread values with the results of the ISO5658 method is not directly possible since the nature of interpretation of the flame spread parameter is different However, the equivalent ranges of values of S_r/m and S_R/m for this parameter measured in the ISO test were 3.3 - 7.6% and 6.5 - 19%.

The test shows the capability to measure flame spread with a reasonable level of repeatability for both lateral and vertical directions. The reproducibility for vertical flame spread is not as good as for lateral spread.

However, the statistical analysis is not very meaningful for this parameter; the number of materials reported from all the laboratories as exhibiting lateral flame spread in excess of the minimum criteria is limited, and as mentioned above there is difficulty in observation of vertical spread. Further consideration needs to be given to the interpretation and use of the flame spread measurement.

3.1.5 Flaming droplets

The measurement of flaming droplets/particles is based on three separate observations, being the time to the first flaming droplet/particle, t_{drip}, the time of the first flaming droplet/particle that remains burning for 15 seconds, t_{drip15}, and the time of the first flow of droplets/particles, t_{flow}.

A statistical analysis of the data available for this parameter was also difficult because of the large number of tests for which there was no data. The only meaningful analysis that could be made was of the values of t_{drip}.

The test provides a mean value for S_r/m not exceeding 30%, and a mean value for S_R/m not exceeding 50%.

The test shows an acceptable repeatability and reproducibility in terms of the determination of the time to the first occurrence of any falling of flaming droplets/particles.

3.2 Inter-laboratory consistency

No analysis has currently been made of the results of the measurement of the different parameters as a function of individual laboratory. This could realise consistent variation by laboratories in their measurement of one or more of the parameters. For example, a laboratory may be consistently high in its measurement of heat release, for whatever reason, and this will have a detrimental effect on the overall repeatability and reproducibility of the method. This is an aspect that could be explored by further statistical analysis.

4. RHR vs. ΔT

Temperature is an easy parameter to measure and utilises well known techniques. In the test the measurement is made in the exhaust duct and the increase in temperature gives an indication of the heat release from the product under evaluation.

The true heat released by the combustion of the tested material is partially emitted by radiation and is absorbed by the surroundings and is partially absorbed by increase of the temperature of the combustion gases. The relationship between these two parts is to some extent product dependent. The temperature increase within the exhaust duct represents the convective part of the released heat only. It more or less neglects the heat emitted by radiation. Depending upon the density, thermal and surface characteristics of the product the heat release as indicated by the ΔT will, therefore, be modified whilst the actual heat release may be similar.

The surrounding to the test equipment may also effect the temperature signal in the exhaust duct. As a consequence of the thermal inertia of the extraction system for the combustion products, the relationship between convective heat release and the temperature increase in the duct will vary over the duration of the test, e.g. for the constant heat release of the gas burner, without any contribution from the product, a steady increase in temperature of the gases in the exhaust duct is measured which will always continue beyond the test duration. That means that the ΔT measurement due to the burner cannot be subtracted as a constant base-line.

In the test, with significant levels of heat release from the specimen, the mass flow rate of the combustion gases is temperature dependent. It varies highly dependent upon the extraction system. A true picture of the convective heat release, therefore, would require the variation of mass flow rate to be taken into account. As long as this is not done the reproducibility of the ΔT measurement, at least for the high heat release materials, will suffer.

The oxygen depletion measurement is a complicated procedure that requires a higher skill level for the operator carrying out the test than for the temperature measurement. It requires frequent checking and calibration of the associated measurement system, including the oxygen analyser. The result, however, covers the full heat release (radiative and convective parts) and is independent of the ventilation system. It allows calibration of the apparatus in a quantifiable manner.

The ΔT measurement and the cumulative ΔT values indicate better repeatability and reproducibility of measurement than the oxygen depletion measured RHR and THR values. However, for the ΔT measurements it is not possible to subtract the component associated with the burner output, and if the comparison is made on a like-for-like basis, that is as a

total value, then we find that the repeatability and reproducibility values are approximately equal. The ΔT shows less overall total spread of the measured values and is, therefore, less discriminatory, which in part will provide for its good repeatability and reproducibility.

In principle both methods can be used for measurement of the heat release. However, the scientifically more exact method is the oxygen depletion method which also provides the measure in a meaningful way, not only for the purpose of classification but also for use in modelling approaches. For quality control purposes the ΔT measurement has the advantage of being cheap and simple.

5. BASIS OF IGNITION TIME

Of the three methods evaluated for the determination of ignition, the best repeatability is provided for the $t_{ign}\Delta 3K$ assessment. However, in absolute values the $t_{ign\Delta}5kW$ provides ignition times that are equal or smaller than the t_{ign}visual ones, whereas for the $t_{ign}\Delta 3K$ tend to be greater. This is illustrated by following table that illustrates the number of cases where the absolute value of the reproducibility standard deviation for time to ignition falls within certain values.

	Number of cases		
Reproducibility std S_R	**Visual**	**5kW**	**3K**
maximum 10 sec	13	15	13
between 10 and 20 sec	8	9	1
between 20 and 100 sec	3	4	7
greater than 100 sec	5	1	8

As already indicated the 5kW value is close to the minimum resolution of the test equipment and a slightly higher value up to 10kW would give an improved repeatability and reproducibility and a better correlation between the absolute value of time to ignition provided in this way and the values given by visual observation.

It is difficult to make a positive visual assessment of the time of ignition in the test and a quantifiable measure has to be preferred. In this respect, the definition of ignition based on the time to a specified level of rate of heat release is preferred.

6. FUNCTIONALITY

The round robin exercise indicated that all the laboratories were able to operate the equipment in a satisfactory manner. The test apparatus has proved to be robust and capable of handling materials with maximum heat release rates of in excess of 200kW.

In total, on each apparatus, over 100 tests have been carried out without any report of substantial damage to the equipment.

There were little problems experienced with the specimen arrangement, and whilst some engineering improvements may still be made to facilitate an easier use of the specimen trolley arrangement, this is also satisfactory.

With a single trolley arrangement it appears possible to test more than a single product per day. With two trolley systems this rate could obviously be increased. As a consequence of the increased in temperature of the exhaust system, especially for the higher heat release products, it is unlikely that any increased rate of testing would be possible.

The oxygen depletion technique, used already in the ISO room-corner test and cone calorimeter test, introduces a level of sophistication and associated precision which is now well known to experienced laboratories and does not represent any difficulties.

7. FURTHER IMPROVEMENTS

Certain improvements can be made to the apparatus that will realise better repeatability and reproducibility of the test results. Further analysis of the test data may also provide some guidance on factors significant in this respect.

Already identified is smoke measurement. There is a need for more attention to the calibration of the smoke measurement apparatus, which is used in other fire tests with little problems. It may only be a reflection of the time period to complete all the tests that pressured the participating laboratories such that insufficient time was devoted to this aspect. Additionally, the use of an air purging system as used in other fire test methods can assist in alleviating the problem of deposits on the lenses of the measurement system.

No attempt has been made to correct the smoke measurement for the different mass flow rates; it is assumed that this will be equal for all apparatus. However, this is not so since the mass flow rate through the apparatus varies as a function of the temperature of the exhaust gases. A correction in this respect may improve the repeatability and reproducibility of the rate of smoke production.

Further guidance should be provided on specimen mounting, especially with respect to the positioning of joints on the walls and within the exposure zone. This will improve the repeatability and reproducibility of the method.

8. CONCLUSIONS

Considering the results from the all the materials tested in the round robin exercise the SBI test shows a good level of repeatability and reproducibility in the measurement of most of the parameters required for the purpose of the Euroclass system. By comparison with equivalent data from other fire test round robin exercises, the values for the associated repeatability and reproducibility standard deviations are comparable. Some consideration of the use of the different parameters within the Euroclass system will enable a better evaluation of the significance of the repeatability and reproducibility figures to be obtained.

In common with most fire tests, problems were encountered with the testing of products that exhibit melting, delamination, etc., that tend to influence the spread of results. Similarly, for some products it was not possible within the scale of the test, to provide meaningful fixing details.

It is considered that some improvements may be possible, both in terms of the specification of the procedure and in terms of the engineering of the apparatus, before the method is published as a European standard. However, the current state of specification is considered adequate as a basis for a mandate to CEN.

9. RECOMMENDATIONS

With some guidance from the Fire Regulators Group on the proposed method of using the parameters within the Euroclass system, a further analysis of the round robin data should be made. That data that lies beyond the classification limit or period can then be excluded from the analysis and this should realise an improved repeatability and reproducibility.

The threshold for the rate of heat release used to indicate ignition should be reviewed with a view to increasing the value to provide for better repeatability and reproducibility and to improve the correlation with the visual ignition level.

Consideration should be given to defining as 'zero' any measured maximum rate of heat release that is less than 5kW . There is little value in this very small level, only to detract from the repeatability and reproducibility.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL III
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Message:

Dear colleague,

Please find enclosed a copy of document RG N124 for next week's meeting of the Fire Regulators Group. It is a report, prepared by some members of the Laboratories Group, to provide further explanation and analysis of the SBI round-robin report. It should help discussions at the meeting considerably.

The only document now outstanding, RG N118 about the use of the reference scenario, will be tabled at the meeting.

Please note that the RG meeting will be held at 1, avenue de Cortenberg, Brussels, (near Schuman) and not at the Borschette Centre as previously announced.

Regards,

p.o.

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