ISO/TC 142/WG 9
Particulate air filter intake systems for rotary machinery and stationary internal combustion engines

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Secretariat:

Air intake filter systems for rotary machinery — Test methods — Part 2: Cleanable (Pulse jet) filter systems

Sytèmes de filtration d'air d'admission pour machines tournantes - Partie 2: Méthodes d'essai et classification pour les filtres auto-nettoyants (dit à jets d'air comprimé à contre-courants")

Warning
This document is not an ISO International Standard. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an International Standard. Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 29461-2 was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*, Working Group 9, *Particulate air filter intake systems for rotary machinery and stationary internal combustion engines*.

ISO 29461 consists of the following parts, under the general title *Air intake filter systems for rotary machinery — Test methods*:

— *Part 1: Static filter elements*

— *Part 2: Cleanable (Pulse jet) filter systems*

— *Part 3: Mechanical integrity of filter elements*

— *Part 4: In-situ testing*

— *Part 5: Marine and Offshore environment filter systems*

— *Part 6: Cleanable (Pulse jet) filter elements*

[*Notes to this draft document: Comments and questions from the editor and project leader, Bruce McDonald are in italics and enclosed in square brackets like this paragraph. xx is used in the document to indicate a reference number to be determined. ?? is used to indicate a section where more information is needed. All such comments should be removed before the document is accepted as a Committee Draft. For example: do global searches for xx, ?? and* [.]

[*This draft version, ISO_29461-2_(E)-140926RBNM.docm is the second draft in the ISO template. It contains a major change from the first draft in the ISO template. The test procedure has been replaced with the procedure that was originally proposed in Task Group. document TGN-04 and was recently presented to WG 9 in ISO-TC142-WG9_N0144_ISO_TC142_-_WG9_-_N144_-_Part2_-_newtest.pdf. N0144 was agreed to at the WG 9 meeting in London 23 Sep. 2014. It is an understatement that the test procedure needs considerably more detail. The Task Group for Part 2 will address that along with the ongoing work on test dust selection.*

[For this revision additions are highlighted in yellow. The additions were made to include our decisions concerning the test procedure and the use of an aerosol photometer .]

For this -140926R revision I removed *Green text, which was instructional material that ISO includes in the template.*]

I strongly recommend that we accept all tracked changes and start tracking new changes. Otherwise the document will get unwieldy with many levels of tracked changes.

The first draft in the ISO template was ISO_29461-2_(E)-140319RBNM.dox. It was based on TestProcedureRev2.docx. The last version distributed to WG 9 was TestProcedureRev1.docx with tracked changes from the February 23, 2011 meeting. When those tracked changes were accepted as part of the document it became TestProcedureRev2.docx. Hence Rev2 has the same content as the last version of the document that was distributed to the WG.

The editor has taken the liberty to rearrange the content of the previous draft to better fit the ISO template.

Additionally, this document includes items that WG 9 agreed to in the meetings since TestProcedureRev2. Those items are inserted as WORD tracked changes. There are also WORD tracked changes where I have made editorial corrections / changes to TestProcedureRev2.docx or where new material has been added that was not in TestProcedureRev2.docx. Note that the appearance of WORD tracked changes may vary depending on the settings in the reader's software. For reference, this sentence was a tracked change when it was inserted. All such WORD tracked changes should be accepted or rejected before this document becomes an official Committee Draft.]

[

[*There was not a Forward in TestProcedureRev2.docx. This Foreword is based on the Foreword to DIS 29641-1. However it is not the same as the Foreword in Part 1. It is changed to be more general – not specific to Part 1. An attempt was also made to give it a consistent structure*. *The first 6 paragraphs of the Forward which are in blue type above are required by ISO.*]

Part 1 describes test methods for determining particulate efficiency, pressure drop of static filter elements, typically of the depth loading type. All filters can be tested in the same manner thus obtaining comparable results. However, for surface loading filters, reverse pulse filters, marine and offshore filter systems as well as other filter systems that are not regarded as static filter units, the appropriate part shall be used.

Part 2 describes test methods for determining energy consumption, particulate efficiency, gravimetric efficiency, restriction, pressure drop and pulse cleaning performance of cleanable filter systems. [*Note addition of energy consumption (compressed air consumption) and pulse cleaning performance to list of variables measured. We may want to find better words for "…pulse cleaning performance…". With no upstream sample, we are not measuring particulate efficiency. What else should it be called?*] [*Note that this current draft of Part 2 includes test methods for cleanable filter systems. It does NOT include test methods for surface loading filters.*]

Part 3 describes test methods for determining the mechanical integrity of filters under conditions that may be encountered in abnormal operating environments.

Part 4 describes test methods of testing filters in real operating conditions (in-situ testing).

Part 5 describes test methods for the specific requirement of offshore and marine application, and specifies test methods for determining the sea salt removal efficiency of individual filters and/or complete filter systems.

Part 6 describes test methods for determining particulate efficiency, gravimetric efficiency, pressure drop, and pulse cleaning performance of cleanable filter elements.

[*The forward of the FDIS for part 1 includes the following paragraph.*

> "For multi-stage systems that use a number of components (equipment for cleaning, filters etc.) this standard may be used as long as the qualification requirements of the test rig can be fulfilled. In cases where this is not possible Part 4 (In-situ testing) procedures may be applied."

That paragraph describes the scope of the document and should not be in the Forward. It is not included here in the Foreword to Part 2.]

[*Per ISO instructions, this is the place to describe the relationship of this document to other documents.*.]

TC 142 / WG 9 used the following documents as background information in the development of this test method:

ISO/FDIS 11057:2010, Air quality — Test method for filtration characterization of cleanable filter media

ISO DIS 19713-1 Road vehicles — Inlet air cleaning equipment for internal combustion engines and compressors — Part 1: Fractional efficiency testing with fine particles (0,3 µm to 5 µm optical diameter)

ASHRAE Research Project RP-1284, “Develop a Standard for Testing and Stating the Efficiency of Industrial Pulse Cleaned Dust Collectors”

(Drafts of) ASHRAE Standard 199 "Method of Testing the Performance of Industrial Pulse Cleaned Dust Collectors"

Annexes ?? of this part of ISO 29461 are normative.

Annexes ?? of this part of ISO 29461 are for information only. [*Information about the Annexes is given in the Foreword in several ISO standards. However, it is not part of the information that ISO requires or suggests for inclusion in the Foreword. It duplicates information in the table of contents that precedes the Foreword. So why is it here?*]

Introduction

Filters in stationary power generating/compressor applications

[*There was not an Introduction in TestProcedureRev2.docx. This Introduction is based on the Introduction to DIS 29641-1. However it is not the same as the Introduction in Part 1. It is changed to be specific to Part 2.*]

In rotating machinery applications, the filtering system, typically a set of filter elements arranged in a suitable manner, are an important part of the whole turbine/compressor system. The development of turbine machinery used for energy production or others has led to more sophisticated equipment and therefore the importance of good protection of these systems has become more important in the recent years. It is known that particulate contamination can deteriorate a turbine power system quite substantially if not taken care of. This event is often described as “erosion” - “fouling” and “hot corrosion” where salt and other corrosive particles are known as potential problems. Other particle matters may also cause significant reduction of efficiency of the systems. It is important to understand that air filter devices in such systems are located in various environmental conditions. The range of climate and particle contamination is very wide, ranging from deserts to humid rain forests to arctic environments to polluted urban environments. The requirements on these filter system are obviously different depending on where they will be operating.

This standard has based the performance of the air intake filter systems not only upon heavy dust collection but also particulate efficiency in a size range that is considered to be the problematic area for these applications. Both ultra-fine and fine particles, as well as larger particles should be considered when evaluating turbine fouling. In typical outdoor air, ultra-fine and fine particles in the size range from 0,01 to 1 µm are contributing to > 99% of the number concentration and to > 90% of the surface contamination. The majority of the mass normally comes from larger particles (> 1,0 µm).

Turbo-machinery filters, comprises a wide range of products from filters for very coarse particles to filters for very fine, sub-micron particles. The range of products vary from self-cleaning to depth loading and/or surface loading systems. The filters and the systems have to withstand a wide temperature and humidity range, very low to very high dust concentration and mechanical stress. The shape of products existing today can be of many different types and have different functions such as droplet separators, coalescing products, filter pads, metal filters, inertial filters, filter cells, bag filters, panel-type, self-cleanable and depth loading filter cartridges and pleated media surface filter elements.

The series of standards will provide a way to compare these products in a similar way and define what criteria are important for air filter intake systems for rotary machinery performance protection. The performance of products in this broad range must be compared in a good manner. Comparing different filters and filter types must be done with respect to the operating conditions they finally will be used in. For instance, if a filter or a filter system is meant to operate in an extreme, very dusty environment the real efficiency of such filter is indicated by the initial and final efficiency, where the dust loading of the filter plays an important role. On the other hand, if the same filter or system is placed in a more common environment where the majority of particles in the air are small and originating from combustion etc., the “conditioned” efficiency would be the important performance factor to look at.

Filtration characteristics

In an ideal pulse cleaned filtration process, each particle would be arrested at the first contact with a filter fibre, release from the fiber when pulse cleaned, and settle out of the upstream air flow after release by pulse cleaning. In real pulse cleaned filters, some particles penetrate the filter. The penetration depends on the amount of particles already on the filter. In a filter that has been operating for some period of time, a substantial portion of the efficiency is due to the filtration provided by the dust cake. The particles penetrating the filter temporarily increase during and immediately after a pulse cleaning event as the dust cake is disrupted and re-established. The efficiency and recovery from a pulse cleaning event depend on the challenge concentration. Therefore, to adequately represent the long term performance of pulse cleaned systems, this test method measures efficiency during complete pulse cleaning cycles while feeding dust. The measured efficiency and pressure loss characteristics apply only to the conditions tested. [*<u>Need to add the other characteristics:</u> energy consumption, restriction, pulse cleaning performance.*] The overall efficiency and pressure loss of a pulse cleaned filtration system depends on the pulsing mechanism, pulse duration and pulse timing. Therefore the results of this test method only apply to systems using the same pulse mechanism, pulse duration, and pulse timing as used in the device tested.

Air intake filter systems for rotary machinery — Test methods — Part 2: Cleanable (Pulse jet) filter systems

1 Scope

[*There was not a Scope in TestProcedureRev2.docx. This Scope is based on the Scope to FDIS 29641-1. However it is not the same as the Scope in Part 1. It is changed to be specific to Part 2.*]

This international standard specifies methods and procedures for determining the performance of cleanable (pulse jet) particulate air filter systems used as air intake filter systems for rotary machinery such as stationary gas turbines, compressors and stationary internal combustion engines. [*There are efficiency limits in Part 1 Scope. What efficiency limits apply to part2?*] The procedures and hardware in this standard are applicable for filter systems which operating at flow rates within the range of x.xx m3/s (4000 m3/h) up to x.xx m3/s (24000 m3/h). [*Is it appropriate / necessary to add "While these test procedures may be applied to systems outside the prescribed flow limits, comparable results may not be obtained because of the hardware modifications that are required to handle other flow rates"?*] [*Section 5.3 contains numerous requirements and restrictions on the systems that may be tested. Should those be listed in the scope or should the scope refer to Section 5.3?*] Further definition the cleanable filter systems that may be tested within the scope of this standard are given in Section 5.3.

System operating parameters measured include:

— Initial restriction [*We are not measuring pressure drop from an inlet duct to an outlet duct, but only have an outlet duct. The static pressure in the downstream duct is the restriction. The total pressure loss needs to be calculated from the restriction and dynamic pressure in the outlet duct. See ISO 5011 Definitions and ISO 5011 Annex A. Also check TC 142 terminology document.*]

— Compressed air consumption

— Initial efficiency

— ~~Efficiency~~ Emissions during dust feeding measured with an aerosol photometer

— Change in restriction during dust feeding

— Recovery from an interruption of the compress air supply

~~Two~~ Three methods of determining the efficiency are used in this standard:

— Particulate fractional efficiency of one element or element pair using DEHS aerosol using the test in ISO 29461-1 (at beginning and maybe at end of test only)

— [We deleted fractional efficiency]~~ This Particulate fractional efficiency using loading dust (measured with respect to particle number and size)~~ [*Its not correct to call this efficiency because we will not measure the upstream distribution and concentration during the test. Perhaps we should just report downstream number concentration at 1 gram/m^3 dust concentration.*]

— Gravimetric efficiency (The percentage weighted mass removal of loading dust)

After determination of its initial particle efficiency, the filter system is loaded with dust in steps. The filter system performance is measured at various stages of loading.

The performance results obtained in accordance with this standard cannot be quantitatively applied (by themselves) to predict performance in service with regard to efficiency and lifetime. Other factors influencing performance to be taken into account are described in Annex xx (normative) and Annex xx (informative) [*Specific Annex references were dropped in anticipation that Part 2 will have different Annexes that Part 1*].

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[T*he references are cited without dates. The WG needs to review the references to determine if it is necessary to include dates with the references.*] [*It is my opinion that the WG should write the standard, then determine what references are needed. What follows are some suggestions of references that are likely to be needed*.]

ISO 12103-1, *Road vehicles - Test dust for filter evaluation - Part 1: Arizona test dust*.

ISO 5011, *Road vehicles - Inlet air cleaning equipment for internal combustion engines and compressors —*

Performance testing

ISO 21501-? *Determination of particle size distribution – Single particle light-interaction methods – Part ??*

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices - Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full*

ISO 2854, *Statistical interpretation of data - Techniques of estimation and tests relating to means and variances.*

ISO 14644-3, *Metrology & Test Methods*

[*A reference to a method for gravimetric sampling from duct or flue e.g.* ISO 11338-1 *Stationary source emissions -- Determination of gas and particle-phase polycyclic aromatic hydrocarbons -- Part 1: Sampling*. – OR – ISO 23210 *Stationary source emissions -- Determination of PM10/PM2,5 mass concentration in flue gas -- Measurement at low concentrations by use of impactors – OR* – EPA Method 5.]

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply / the terms and definitions given in … and the following apply.

[*It is my opinion that the WG should write the standard, then determine what specialized term need to be defined. The definitions included in this document need to be compared to ISO 29464 and to the ISO data base. What follows are some suggestions of term that are likely to be needed.*]

4.1
Cleanable filter system
A filtration system cleaned with compressed air during operation including all hardware from immediately upstream of the filter elements to downstream of the cleaning system[1)]

1) see Section 5.3 for more detailed description of what components are included and not included in the system to be tested per this standard.

4.2
cleaning pulse
the release of compressed air that occurs at the one time

4.2
Complete pulse cleaning cycle
A series of cleaning pulses such that all locations in the filter system are cleaned once[2)]

4.3
Restriction
The difference in static pressure between ambient pressure and downstream of the filter system under test before the contraction

4 Symbols (and abbreviated terms)

[*To be completed after the necessary equations are written in the document.*]

5 Test rig and equipment

5.1 Test conditions

The temperature shall be between 15 and 25 C. The relative humidity shall be between 40 and 60%. The tests shall be conducted at local ambient barometric pressure. If the ambient air density is not in the range of 1,16 kg/m3 and 1,24 kg/m3, then all restriction measurements shall be corrected per Annex xx.

5.2 Test Request

The test request must include:

— Test air flow rate

— Compressed air supply requirements; flow and pressure

— Compressed air system volume (see section xx)

— • test unit with Filters

— • Compressed Air requirements [pressure and volume flow rate to accomplish conditioning, Volume of compress air storage from system inlet to pulse valve including reservoir and fittings and piping.]

— • Power Requirements

— • Pulse Settings [does std need to specify upper and lower pressures to facilitate comparisons?] and instructions to disable pulsing, to change from pulse on demand to defined (10 sec.) timed pulsing, and to change back to pulse on demand.

— • Connections for laboratory to measure the pressure differential that is used to trigger pulse cleaning when operated in pulse on demand mode.

— • Specified Airflow

2) because of the requirement that no more than 1/4th of the filter system be cleaned at one time, a complete pulse cleaning cycle will consist of at least 4 cleaning pulses

— • outlet duct connection adapter, and inlet shroud

— • User manual.

— • All information required to safely operate the system

— Drawing with basic dimensions: element size and location,

— What the Tester provides

— • aerosol mass concentration monitor, and aerosol sampling equipment for obtaining mass efficiency measurements.

— • outlet [ducts] devices including: pressure taps for system pressure drop, aerosol mixing, aerosol sampling, exhaust filters and flow measurement

— • Variable flow controlled blower with automatic control of volume flow

— • Data acquisition equipment/software

— • Test Dust

— • Temperature and humidity controlled environment

— • Compressed air supply

— • Power supply for dust collector controls.

5.3 System to be tested

5.3.1 General requirements for system to be tested

The system to be tested shall be programmed for the pulse cycle and pulse duration as the system is to be sold and installed. If the system to be sold pulse cleans more than one element per pulse, the test system pulsing equipment must be scaled to provide that same pulse to a single element. [*Bruce: foregoing assumes one element per pulse in the system to be tested. Suggest changing it to the more general: If the system to be tested pulses a different number of elements per pulse than the system to be sold, then the pulse hardware in the test device must be scaled to provide the cleaning pulse per element as the system to be sold*.] The system must include the capability to disable pulsing and do continuous pulsing.

Option: include dust extraction system. If no dust extraction system, then use shroud as shown in Fig xx.

Test requester must supply the downstream contraction per Section ?? [*Should we require test requester to provide the upstream shroud also?*]

The system to be tested shall include at least 4 filter element mounting locations. There may be more than one filter element per mounting location in the case of stacked element designs. There shall be at least 4 individual pulse cleaning valves. No more than ¼ of the elements shall be cleaned at one time.

The system to be tested shall have a minimum design flow rate of 4000 m3/h (~2350 cfm). Max 24000 m3/h

The system to be tested shall be representative in function of the system to be sold and installed including all components from immediately upstream of pulse cleaned filters to immediately downstream of pulse cleaning mechanism.

The filters are to be mounted in the same orientation as in application. The system to be tested shall not include any equipment such as prefilters and rain hoods upstream of the pulse cleaned filter elements. A shroud to contain the test dust shall be fitted to the system. The shroud shall be as shown in Figure XXThe system to be tested shall not include any filtration downstream of the pulse cleaned filters. [*? Should two stage systems be included?*]

The system to be tested may have horizontal flow or vertical up flow.

5.3.2 Horizontal flow system requirements

[*I had trouble shrinking the sketches and getting them to paste correctly into the ISO format. Please refer to the separate file ISO-TC142-WG9_N0121_ISO_TC142_-_WG9_-_N121_-_part_2_-_System.pdf*]

[*Additional material is needed here to describe what we mean by the sketches.*]

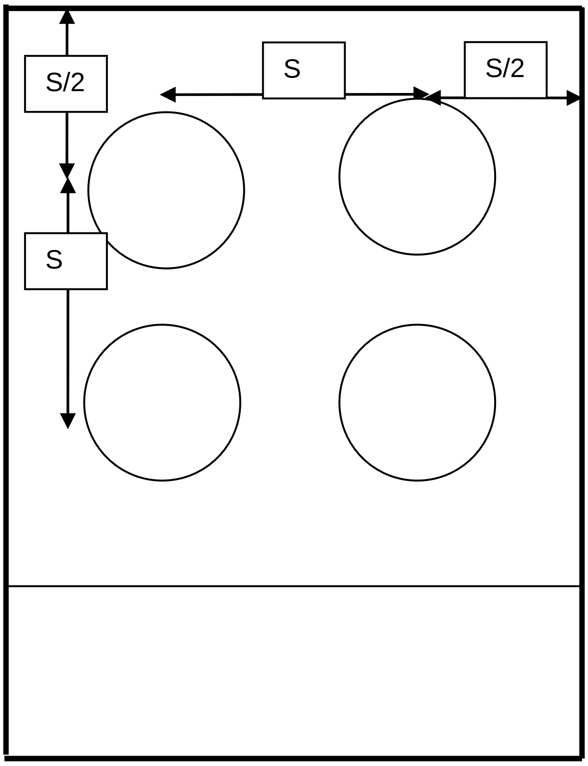


Figure 1 — View into inlet of horizontal flow system

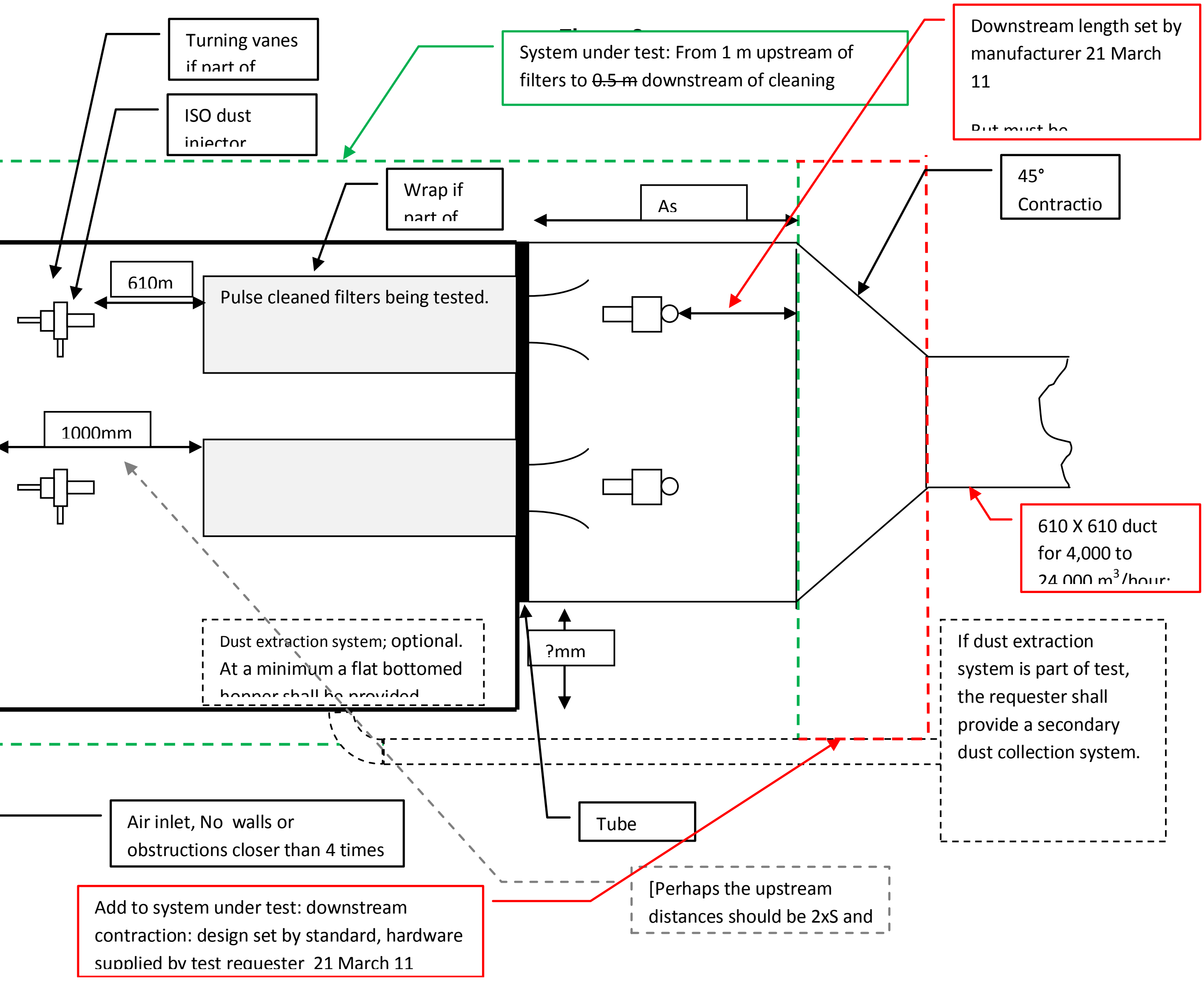


Figure 2 — Horizontal flow system schematic

5.3.3 Vertical up flow system requirements

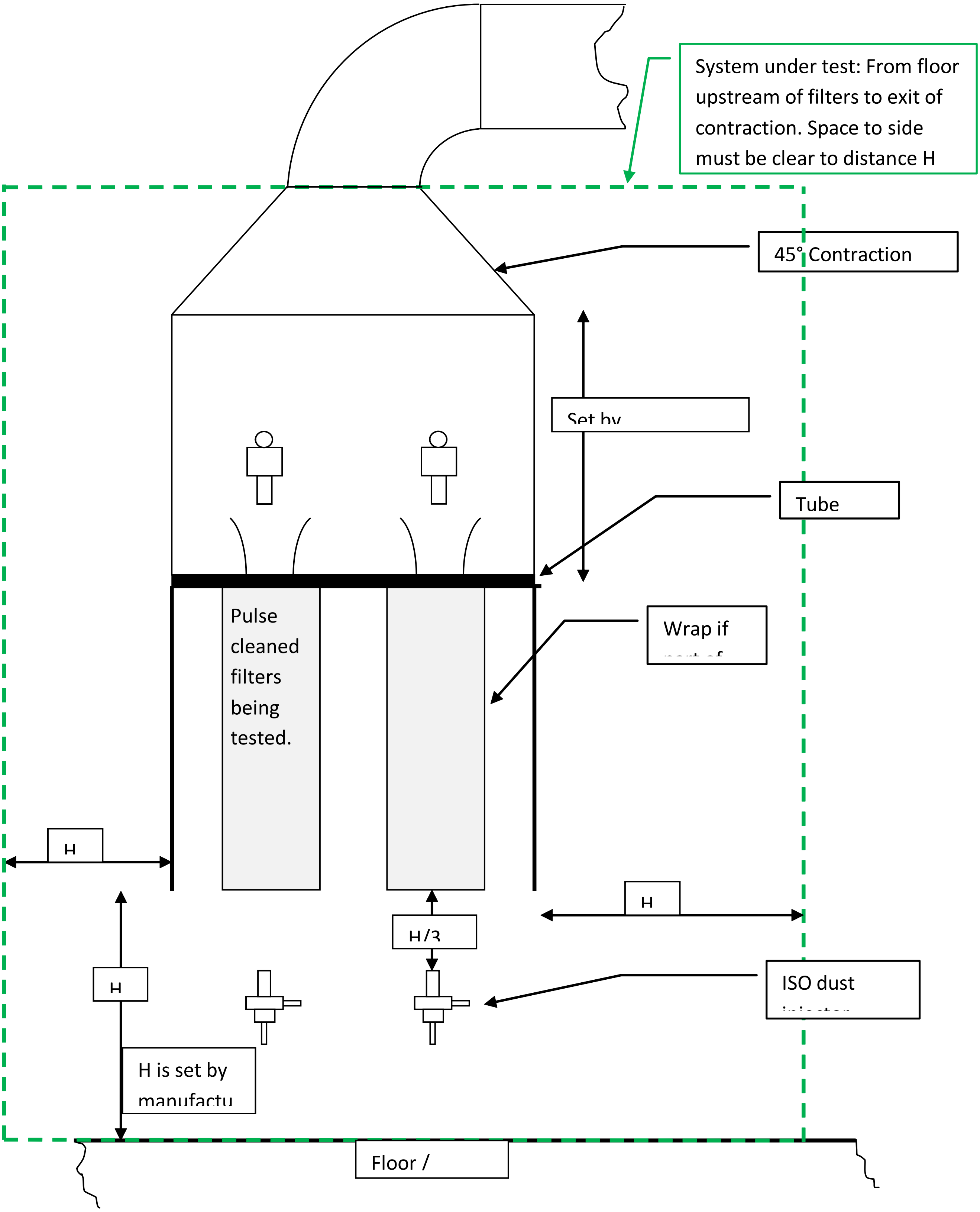


Figure 3 — Vertical flow system schematic

5.4 Distribution of aerosol upstream of filters under test

5.4.1 Dust metering

Metering the dust may be done with equipment such as an auger feeder with all parts contacting the dust stainless steel [*ref. needed*]. The dust metering equipment must be able to maintain the specified dust feed rate +/- 5% as described in ISO 5011 [include test method]. [?require loss of weight automatic feedback controlled dust feeder] [*If we use "…may be…", then do we need to list other options? Is it appropriate to use "…may be…"?*]

NOTE It is necessary to define the dust feeder and material of construction so that the electrostatic charge on the dispersed test dust will be similar for all test systems .

If one dust metering device is used to supply dust to more than one dust injector, additional tests must be conducted to demonstrate that dust is divided equally between the injectors ± xx% [*Need data on what is possible and reasonable. Need test method*.] [?allow split before or after dust injector]

5.4.2 Dust transfer tube between metering device and injectors

The material of the tube shall be 316 stainless steel. The diameter of the tubing shall be such that the velocity in the tube is between X and Y m/s [*need range of conveying velocities for the test dust the WG 9 eventually chooses*]. The dust transfer tube shall be grounded. Short sections may be flexible vinyl tubing. The total length of vinyl tubing shall not exceed 0.3 meter. [*It would be difficult to neutralize the dust at the feed rates involved in this test. Specifying the material of surfaces that the dust contacts and transport velocity is an attempt to standardize the charge on the test dust*.]

5.4.3 Dust dispersion

Dust shall be dispersed using compressed air and dust injectors as specified in ISO 5011. At least one dust injector is required for each filter element mounting location. [*Goal is uniform distribution of dust*.] More dust injectors may be used as necessary to provide the required dust injection rate. The material of dust injector that may contact the dust shall be 316 stainless steel and vinyl as specified in ISO 5011. The dust injector(s) shall be grounded.

[*Editor's note: example air flow and dust feed rate: 1 m^3/s X 1 g/m^3 X 60 sec/min /4 = 15 g/min per element. That is in the range for using one small ISO 5011 Figure B.2 dust injector per element. But if the flow rate is doubled, the dust feed rate falls in the range for using a small dust injector or a heavy-duty dust injector ISO 5011 Figure B.3 per filter element. See Table 1 in ISO 5011. How do we want to handle that choice of a small injector or a heavy-duty injector? ISO 5011 is not clear on this. This may not be a common problem if we specify a dust feed rate of say 500 mg/m^3 and air flow rates are in the range of .94 to 2 m^3/s.*] [Wear issue: visual check for wear]

[*Need to include sections from 5011 or add date to the 5011 reference*]

[*It may be a good idea to include a warning here about potential build up static charge. E.g. Metering and dispersing a test dust, then transporting it at high velocity to the filter system being tested results in tribo-electrically charging the dust particles. When charged particles are transported from one location to another, very high static charges can accumulate. It is very important that all parts of the dust metering and dispersion system along with the entire filter system being tested Be well grounded.*]

The outlet of the dust injectors shall be located 610 mm upstream of the most upstream portion of the filter elements under test for horizontal flow. [*Add criteria for vertical flow*] The outlet of the dust injectors shall be directed toward the filter element under test. If one dust injector is used per each filter element mounting location, it shall be located on the centerline of the filter element under test.

If more than one dust injector is used per element mounting location, they shall be arrayed on circle with diameter equal to ½ of the maximum cross sectional dimension of the filter element under test. The dust injectors shall be located equidistantly around the circle.

5.5 Test duct

610 x 610 grounded metal. for flows between 4000 and 24,000 cubic meters per hour. If flow is higher, larger size square duct is allowed to maintain the duct velocity between 3 and 18 m/s.

[*Note that in addition to dust transport issues, the duct size affects the restriction measurement if the restriction measurement is made between ambient and the downstream duct. In the definitions restriction is defined as being between ambient and duct downstream of the filter but upstream of the contraction to 610x610.*]

5.6 Aerosol sampling in test duct downstream of filters

Performance based Mixing in test duct per [*? Use ASHRAE or ?*]

Center line sample

Iso-kinetic

Need both gravimetric and aerosol photometer sampling points

Need reference or detailed description. ? VDI 2066 [Bruce look at aerosol handbooks ask David Pui]

5.7 Blower and flow controls

The blower and flow controls shall be sized to maintain the specified test flow rate throughout the test.

5.8 Flow measurement

The flow shall be the actual volume flow rate at the entrance to the system, i.e. volume flow rate at ambient temperature and pressure. [*Reference appropriate ISO standard*. Jack]

5.9 Aerosol photometer

[*Borrow from ASHRAE SPC 199*]

5.10 Equipment for obtaining sample for gravimetric efficiency

[The r*ecommendation in ASHRAE 1284 RP is to use a calibrated gas meter and membrane sampling protocol similar to EPA method 5. b. Membrane sampler material shall be Teflon with a minimum micron size of 0.3 µm. Need appropriate ISO reference here and more detail*.]

[*probe, tubing and sample holder must be conductive (metal) and grounded. The particles to be sampled may be highly charged and samples may be compromised if equipment is not conductive and grounded. Need to include test for resistance to ground from all components.*]

6 Qualification of test rig and apparatus

Prior to initial use the test system and components shall be validated per the table XX in Annex XX

[*Add test for erosion of dust injectors like that in ASHRAE 52.2*.]

IMPORTANT - If the test set up undergoes any hardware/component changes, the test set up needs to be re-verified and re-evaluated for that portion of the test stand and for those changes.

The validation certifying the performance of a system in accordance to this standard shall be documented including the following:

a) System diagram and detailed description, including dust feeder used

   1) manufacturer and model of the Aerosol photometer;

b) Calibration data for flow measuring device

c) Calibration data for restriction measurement

d) System performance on flow uniformity at downstream sampling location

e) System performance on particle concentration uniformity at downstream sampling location

f) Sample test data

g) Sample test data showing the repeatability of test results

7 Test materials

7.1 Test dust

The loading test dust is to be determined.

7.2 Test dust storage and preparation

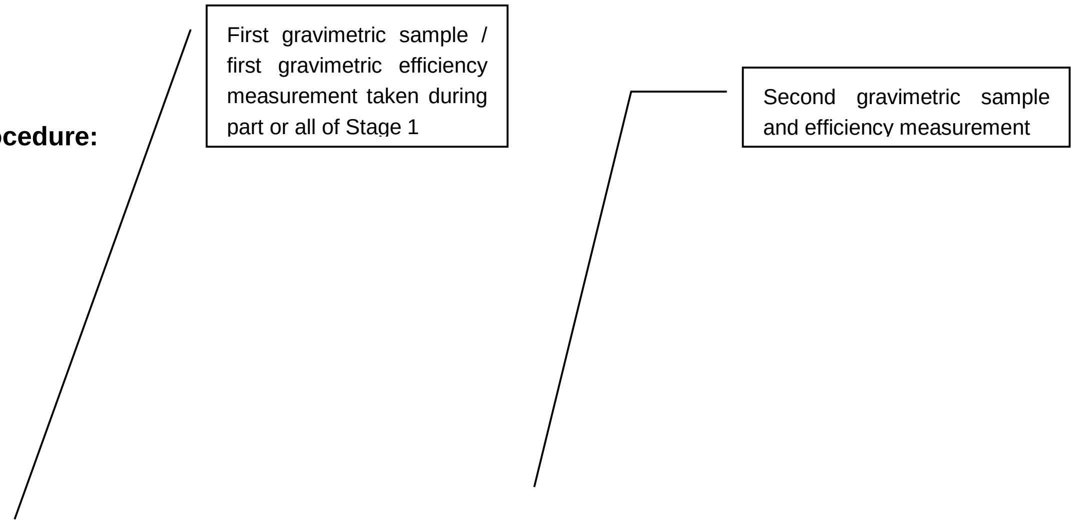
7.3 Recirculation of loading dust

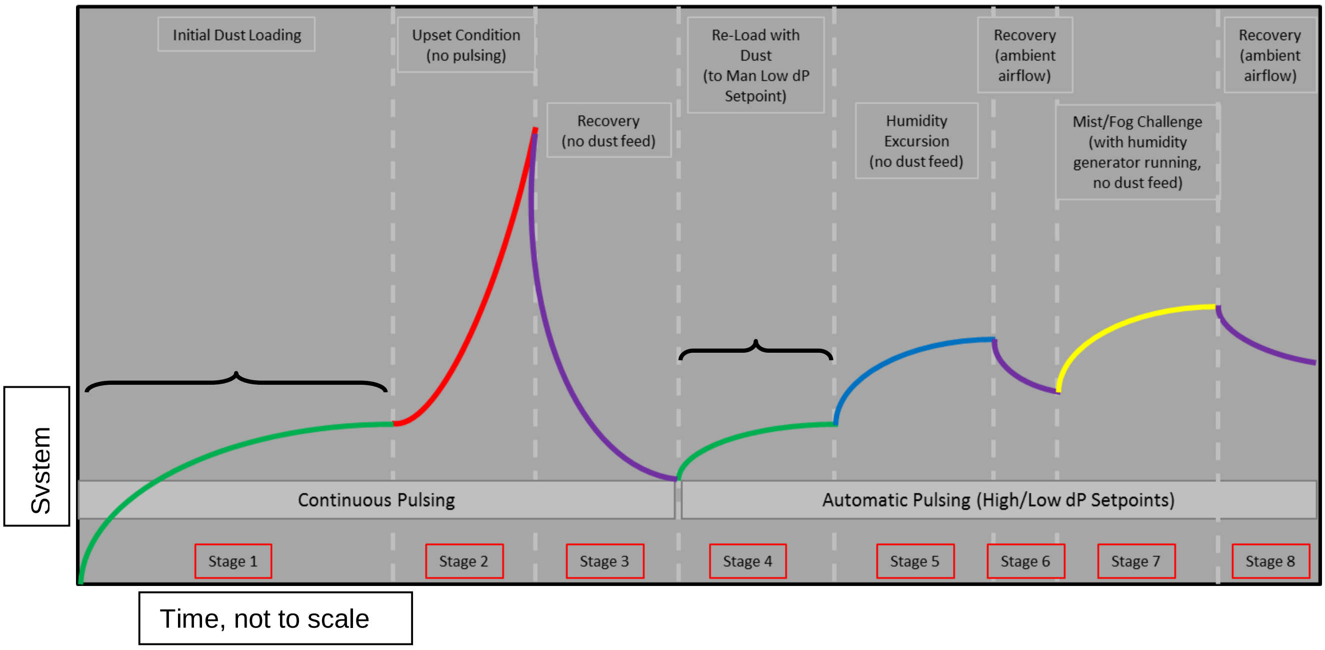
Option 1. Loading dust may not be re-circulated.

8 Test procedure

[!!!*NOTE!!!* *This entire section was removed and replaced with the outline of the new procedure*]

The test procedure:




Initial Dust Loading
Upset Condition (no pulsing)
Recovery (no dust feed)
Re-Load with Dust (to Man Low dP Setpoint)
Humidity Excursion (no dust feed)
Recovery (ambient airflow)
Mist/Fog Challenge (with humidity generator running, no dust feed)
Recovery (ambient airflow)
Continuous Pulsing
Automatic Pulsing (High/Low dP Setpoints)
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Stage 6
Stage 7
Stage 8
System
Time, not to scale

8.1 Outline of steps in test procedure

Once dust loading starts in Stage 1, the air flow to the filter system shall be maintained at test flow rate until the final measurement is made in step d) 3). [*Must add: Relative humidity must be maintained within the range allowed in section 5.1 Test conditions.*]

	Test	Pulse	Dust Feed	End Criteria
29461-1	Initial Efficiency	No Pulse	Off	
PreTest	Flow/dP curve	No Pulse	Off	
Stage 1	Dust Loading and gravimetric efficiency	Continuous (Pause after 20 hours to insert gravimetric sampler)	On	24 hrs
Stage 2	Upset Condition	turn pulsing off	On	10"H2O (expected within 8 hours)
Stage 3	Recovery	Continuous	Off	16 hours (or overnight)
Stage 4	Re-load with dust-salt mix to Low dP set point and gravimetric efficiency	Automatic (High/Low dP set points)	On	Manufacturer's Low dP setting
Stage 5	Humidity Excursion		Off	8 hours
Stage 6	Recovery		Off	10 hours minimum (or overnight)
Stage 7	Mist/Fog excursion		Off	8 hours
Stage 8	Recovery		Off	16 hours (or overnight)
29461-1	Post test Efficiency	No Pulse	Off	[?? Removing element after test is very dirty operation. May not be suitable for measuring efficiency after test.]

8.2 Preloading phase

8.2.1 Set up and preparation of test system

[*Editor envisions that this step includes activities such as*

- *.*
- *Adjust dust feeding equipment to get the proper feed rate. Done by mass per unit time without dispersing dust.* [*It will be much easier to require the feeder be on a scale and include active feedback control of mass feed rate.*]
- *?? verify that compressed air source is adequate, run pulse system without flow and without elements to determine time for pressure in compressed air reservoir to return to set point. Must be less than minimum time between pulses.*
- *?? We need some method to determine if the loading dust is being uniformly distributed and specification of what variance is acceptable.*]

8.2.2 Compressed air consumption

1) The manufacturer of the dust collector shall provide:

   i) The volume of the compressed air manifold system (m^3). This volume shall include all volume from the compressed air connection point to the valves used for pulse cleaning.

   ii) The compressed air supply pressure, quantity, and quality requirements.[*reference to ISO compressed air quality standard would be good here.*]

2) Compressed air, per manufacturer's requirements, shall be connected to a leak free shut off valve and a calibrated air pressure gauge of appropriate scale to the suppliers pressure requirements. The gauge shall be between the shut off valve and the compressed air connection of the dust collector.

3) The volume of the compressed air between the shut off valve and the connection to the dust collector shall be measured or calculated (m^3).

4) After the compressed air system of the dust collector is pressurized to the supplier's provided requirement, the shut off valve shall be closed and the pressure recorded at least 30 seconds after the cleaning system is pressurized.

5) With the shut off valve closed, pulse the collector once using the controls of the dust collector. The pressure shall be recorded at least 30 seconds after the cleaning system has pulsed.

6) The volume of air used (m^3) shall be calculated by multiplying the sum of the volumes in 1) and 3) by the difference in the pressure measured in 4) and 5) and dividing by ??? [*Constant is 14.7 when volume in ft^3 and pressure in ??psi*].

7) Steps 4) through 6) shall be repeated for each valve on the cleaning system.

8) The average air volumes reported in steps 6) and 7) shall be calculated and recorded as cubic meter per pulse. This value shall be used to determine compressed air usage on continuous cleaning () and on demand cleaning by multiplying the number of pulses by the average volume cubic meter per pulse divided by the duration (minutes) of the test phase.

8.2.3 Clean restriction measurement

Measure the restriction of the system at 25%, 50%, 75%, 100%, and 125% of the specified test flow rate.

[*Note that the section of the test procedure to measure the velocity at the upstream sampling location has been drop because the WG agreed to downstream only sampling.*]

8.3 Stage 1; Dust Loading and gravimetric efficiency

8.4 Stage 2: Upset Condition

8.5 Stage 3: Recovery

8.6 Stage 4: Re-load with dust-salt mix

8.7 Stage 5: Humidity Excursion

8.8 Stage 6: Recovery

8.9 Stage 7: Mist/Fog excursion

8.10 Stage 8: Recovery

9 Analysis of data

9.1

[*Notes: need to include:*

Change in mass of gravimetric sample shall be at least 10 times the resolution of the scale used. [need statement of accuracy / resolution]

Must use standard report format for first page of report.

Where we specify reporting a slope of a restriction curve, we need to provide method: average slope over what period of time?? E.g. Least square fit to last 30 minutes of data]

10 Reporting

10.1 General reporting requirements

Test results shall include description and specifications of system tested. The test results are specific to the design tested, the test dust, and the conditions of the test e.g. the flow rate, the pulse cleaning cycle, and cleaning pulse duration.

Include photographs of device under test and test set up.

Annex A
(normative)

Accuracy requirements, validation, and routine operation

A.1 General

[*The following was lifted from ISO DIS 19713-1. Some changes have been made to customize it to the needs of the current project. For example references to neutralizing the efficiency test aerosol have be deleted. There still likely are things that need to be changed*.]

The following are lists of the items that need to be designed in, verified, measured, calibrated, and/or certified to insure that a test system meets the intent of this test standard. This test standard describes the required performance of the test system rather than requiring specific hardware and specific procedures. Hence it is incumbent upon the builder and user of the test system to verify that the required performance is in fact achieved.

Table A.1 (Instrument Accuracy Requirements) contains instrumentation accuracy and other requirements that are generally established by the instrumentation used in the test system. The criteria for most items on the Instrument Accuracy Requirements list are met with traceable calibration. Table A.2 (Validation) contains system characteristics that are established by system design. These characteristics need to be measured once to verify the system design and to verify the initial performance of the test system. The criteria for most items on the Validation list are verified by measurement of the characteristic of the test system. Clause 6, 76 Qualification of test rig and apparatus gives requirements for documenting the test system validation. Table A.3 (Routine Operation) contains calibrations, measurements and activities that need to be repeated on a scheduled basis to insure the continued repeatability and reproducibility of the test system.

Section numbers in the Tables refer to the section of this document where the information may be found.

The order in which the validation tests are done is important. The order given in Table A.2 may be used as a guide. See also Table A.3 Routine operation.

Table 1 — Instrument Requirements

Section	Description	Criteria	Comments
	Air flow rate measurement accuracy	±2% of reading	±2% repeatability
	Air velocity measurement accuracy	±3% of reading	
	Pressure loss measurement accuracy	±1% of reading	
	Temperature measurement accuracy	±5ºC	
	Relative humidity measurement accuracy	±2% RH	
	Barometric pressure measurement accuracy	±300 Pa	
	Particle counter size range	0,3 to 10	Optical size

Table 2 — Validation (Measurement devices and procedures)

Section	Description	Criteria	Comments
	Test system, conductive and grounded		Verify with continuity tester
	Temperature control	20±5°C	
	Relative humidity control	50±10%RH	
	Test duct air leakage		[*Need better measure here*]
	Flow rate control accuracy, shall be accurate as mounted in system	±5% accuracy	±2% repeatability
	Air flow uniformity at downstream sampling location	±10%	
	Pressure loss measurement accuracy	±2%	
	Sample probe iso-kinetic	0% to ±20%	Calculated from flow rates and duct dimensions downstream.
	Sample probe location, upstream, centered,		
	Sample probe location, downstream, centered, at least 7 x D downstream and 4 x D upstream of any bends and obstructions		
	Sample line design and conductivity		Inspection and electrical continuity to ground
	Dust feeder stable concentration	±5%	Same as ISO 5011
	Dust feeder concentration	1g/m^3	Same ISO5011
	Dust feeder size distribution in test duct		Use ISO 5011 dust injector or demonstrated equivalent
	Particle counters, primary size calibration with PSL		According to manufacturer specification
	Aerosol, concentration below particle counter limit to prevent coincidence.	Maximum of 5% decrease	Procedure in Annex D
	Repeatability, pressure loss and efficiency	±5%	To be done at start up and annually
	Reference filter test	Set Baseline	Use to monitor changes in test system performance
	Performance certification documentation	N/A	For the test system validation to be complete it shall be documented

Table 3 — Routine operation

Section	Description	Criteria	Frequency[a]	Comments
	Particle counter zero check		Weekly	Maximum 10 counts per minute per channel
	Reference filter pressure loss and fractional efficiency before dust loading		As required to maintain accuracy	Track for changes. Recommended daily tests
	Particle measurement device calibration		Yearly	According to manufacturer specification
	Air flow uniformity	±10%	Hardware change	Each new filter mounting geometry or after any changes to the test system
	aerosol, uniformity (within each size channel) 0,3 µm to 5 µm and 5 µm to 10 µm	±10% and ±20%	Hardware change	Each new filter mounting geometry or after any changes to the test system
	Dust feeder stable concentration	±5%	New design or test flow rate	
	Loading test aerosol concentration	1g/m^3	As required to maintain accuracy	Refer to ISO 5011

Section	Description	Criteria	Frequency[a]	Comments
	Coincidence error		Annually or change	
	Leak test		Every Test	Visual inspection
	Calibration of air flow measurement	±2%	Annually	
	Calibration of pressure loss measurement	±2%	Annually	
	Calibration of other instrumentation (temperature, relative humidity, etc.	±5%	Annually	Per instrument manufacturer's recommendations or Annually
	Cleaning of test duct and components		After every test	Discretionary as needed
	Dust disperser wear test		??	?? need test method like that in ASHRAE 52.2

[a] Change refers to any change in the test system that might affect the performance.

Annex B
(informative)

complete sample test request and sample test report.

Bibliography