Reducing fugitive emissions by use of Rupture Disc safety devices

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Objectives

- Establish a background for understanding Rupture Disc properties and applications
- Give an overview of RD technology and common models
- Make a comparison between RD and PSV
- Highlight maintenance requirements of PSV

Objectives

- Explain how RD may be used in conjunction with PSV
- Identify main applications and advantages
- Show the reduction of fugitive emissions by use of RD

Rupture Disc properties and applications

- Rupture Discs are **Pressure Safety Devices** designed to protect plants and equipment from overpressure conditions
- RD are **differential** devices: they open when the pressure difference between upstream and downstream is above the set pressure
- RD are **non-reclosing** devices: Once the disc has opened, it will not re-close (and all the fluid is discharged)

Rupture Disc properties and applications

- Opening (or bursting) is a very **rapid** phenomenon and therefore the RD is able to protect equipment also from very steep pressure increase.
- RD is a **simple** device that does not require maintenance, however it may be convenient to check, and eventually change, the disc in occasion of planned plant inspections

Rupture Discs safety devices: materials, design, fabrication, and performance.

- **Material**:
  - First choice is metal, especially Stainless Steel (AISI 316) or high performing alloys like Inconel, Hastelloy, Monel, but also Nickel, Titanium, and Tantalum.
  - The rupture disc is thin and therefore expensive materials are commonly used.
  - Graphite is also used in many cases, especially when the disc is used in contact with highly corrosive fluids

Design

- RD are manufactured according to 4 main designs
  - A) Solid (metal or graphite)
  - B) Composite
  - C) Scored forward acting
  - D) Scored reverse acting

Solid (metal or graphite)

- These discs are flat or domed in the direction of the bursting pressure and are formed by a single layer of metal of graphite

Solid (metal or graphite)

- Rupture pressure depends from 3 factors
  - Material properties
  - Material thickness
  - Active diameter

Solid (metal or graphite)

- Performance:
  - Useful for gas and liquids
  - Burst in a non-predictable geometry
  - Fragment
  - “Wide” burst tolerance
  - “Low” operative margin
  - Generally used for small diameter, low cost applications

B) Composite

- These discs may be flat or domed in the direction of the bursting pressure

B) Composite

- They are made of at least two layers:
  - One metal layer with calibration slits (or through cuts)
  - One continuous layer that ensures gas tightness (normally a film of PTFE or other suitable polymer, but also a thin metal layer may be used)

B) Composite

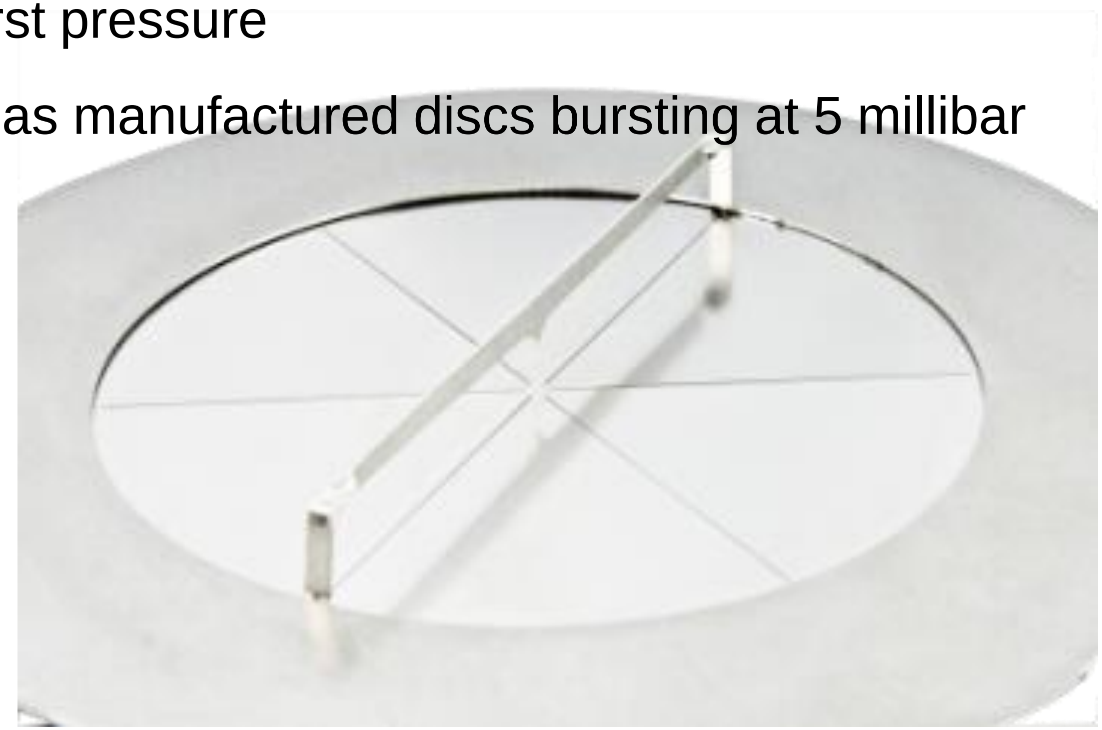
- Rupture pressure calibration is obtained by selecting design and length of the cuts. This operation is now performed normally with laser cutting
- When the differential pressure approaches the set pressure the disc will deform and burst in tension

B) Composite

- Burst tolerance and operating ratio are generally better than in solid discs
- These discs may be used for gas and liquids
- The calibrated part of the disc will not fragment; the membrane will fragment (but if it is a thin PTFE film, fragmentation is going to have little or no impact)

B) Composite

- The composite disc design allows the manufacturing of RD with low and very low burst pressure
- **DonadonSDD** has manufactured discs bursting at 5 millibar



C) Scored forward acting (tension loaded)

- These discs are made with a single metal layer and are (generally) domed in the direction of the bursting pressure.
- Calibration is obtained by scoring
- Rupture pressure depends from design and depth of the scores

C) Scored forward acting (tension loaded)

- Scored discs have a lower tolerance than solid and composite discs and better operative ratio
- They are adequate for gas and liquids
- They do not fragment
- The scores are generally made by scoring with a die

C) Scored forward acting (tension loaded)

- **DonadonSDD** has developed and patented a **laser scoring** process
- This process is extremely precise and reproducible and allows maximum flexibility in score design(e.g. 6 or more petals instead of 4 as all competitors)
- We can score without defects even very thin (20 micron) sheets

C) Scored forward acting (tension loaded)

- No mechanical tool that may wear with time is required
- Production planning is very flexible because set-up is fast and simple and therefore very fast deliveries are possible

D) Scored reverse acting discs (compression loaded)

- Scored reverse acting discs are **domed against the direction of the bursting pressure** and made with a single layer of metal.
- Calibration depends on the resistance to compression of the dome.
- When the pressure differential between upstream and downstream reaches the set pressure, the dome will reverse and then tear along the scores

D) Scored reverse acting discs (compression loaded)

- This design allows very tight tolerance and very good operating ratio
- Resistance to repeated pressure cycles is also extremely good.
- They are adequate for gas and liquids but full liquid applications require special care because of possible pressure drop during the reversal / opening phase
- They do not fragment

D) Scored reverse acting discs (compression loaded)

- There are two main designs:
  - The common design is with the score along the circumference (perimeter)
  - The disc will open with one petal retained by a non-scored sector and, eventually, by a dampener

D) Scored reverse acting discs (compression loaded)

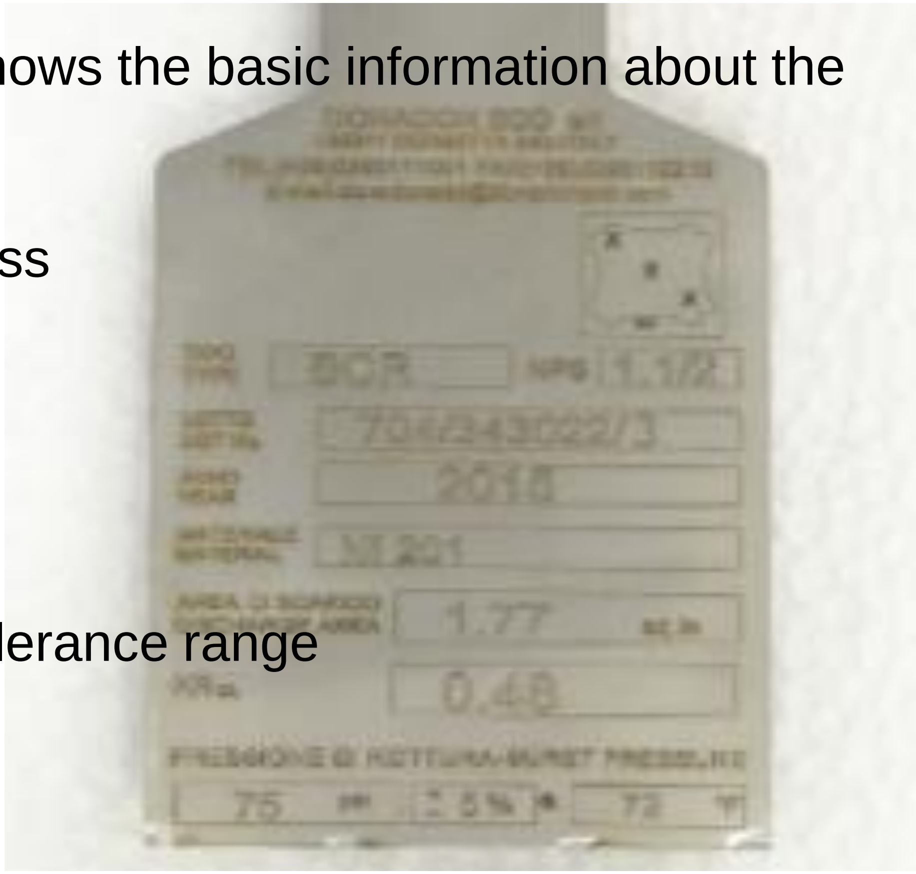
- Also cross scored design is possible.
- Rupture discs with this design have better resistance to fragmentation and maximum discharge area

D) Scored reverse acting discs (compression loaded)

- The **DonadonSDD SCR** model (cross scored with 6 petals) has a discharge area superior to that calculated for the inscripted hexagon and a certified flow resistance coefficient ($K_{Rg)}$) of 0,48.
- This means that head loss through the RD is less than that caused by a pipe length of half diameter)

The TAG

- The tag attached to the disc shows the basic information about the device, including:
- Manufacturer name and address
- Type, model and size
- Year of manufacturing
- Material
- Nominal burst pressure and tolerance range
- Discharge area



Pressure Safety Valves and Rupture Discs

- Pressure safety (relief) valves belong to 4 families
  - Weight loaded
  - Spring loaded
  - Pilot operated
  - Electrically actuated
- Following comments are mainly referred to spring loaded PSVs

Comparison between RD and PSV

- Both devices protect from overpressure
- RD is simple, PSV is mechanical
- RD may be installed in every position; PSV must be installed in vertical position
- When the overpressure condition that has caused the opening of the device ceases, PSV recloses, instead RD will not reclose,

Comparison between RD and PSV

- Pressure Safety Valves may leak through the seat especially
  - If used for corrosive or fouling fluids.
  - If used near the set point
- Testing, inspection and maintenance of PSV are required at regular intervals in order to avoid that:
  - PSV fails to open at set pressure;
  - Leaks through the seat

Maintenance of PSV

- Experimental data on PSV performance show that PSVs require regular and well planned maintenance activities in order to:
  - Ensure correct opening pressure
  - Avoid leakage

Maintenance of PSV

- The inspection process consists of:
  - **Pre-test**.
  - **Disassembly**.
  - **Reparation**.
  - **Assembly**.
  - **Spring Adjustment**
  - **Valve testing**.

Maintenance of PSV

- It is good practice to test, internally inspect, and maintain Pressure Safety Valves at regular intervals. The reasons are:
  - PSV reliability can be assured only if they are tested at the proper frequency
  - The probability of a PSV failure on demand increases with time since last inspection
  - The pre-test, internal and external inspections provide valuable information for possibly modifying the inspection frequency
  - Maintenance improves probability that the PSV are in good condition and successfully operate if needed
  - Reliability knowledge for each specific PSV can then be obtained

Maintenance of PSV

- It is an expensive process!
- However there are very good reasons for doing it regularly

Published studies

Published studies support these considerations with impressing statistical data

- 1) **Pre-test sampling of 12.790 PSV's (Smith 1995) :**
  - 13% safety valves did not lift at 10% above set pressure
  - 5% safety valves did not lift at 50% above set pressure
  - 3% safety valves did not lift at twice set pressure

Published studies

2) **Pre-test sample of 866 PSV’s (Aird 1982) :**

- Criteria that a failure happens if the valve is lifting at ± 10% of the set pressure:
    - A mean of 44.5% of the valves lifted outside the ± 10% range
    - Besides dirt on the seats or product clogging the entrance, other mechanisms also affected PSV performance: spring relaxation, vibration and low temperature

Published studies

3) **Inspection of 45 PSV's during the turnaround of a petrochemical plant (Basco 2016) :**

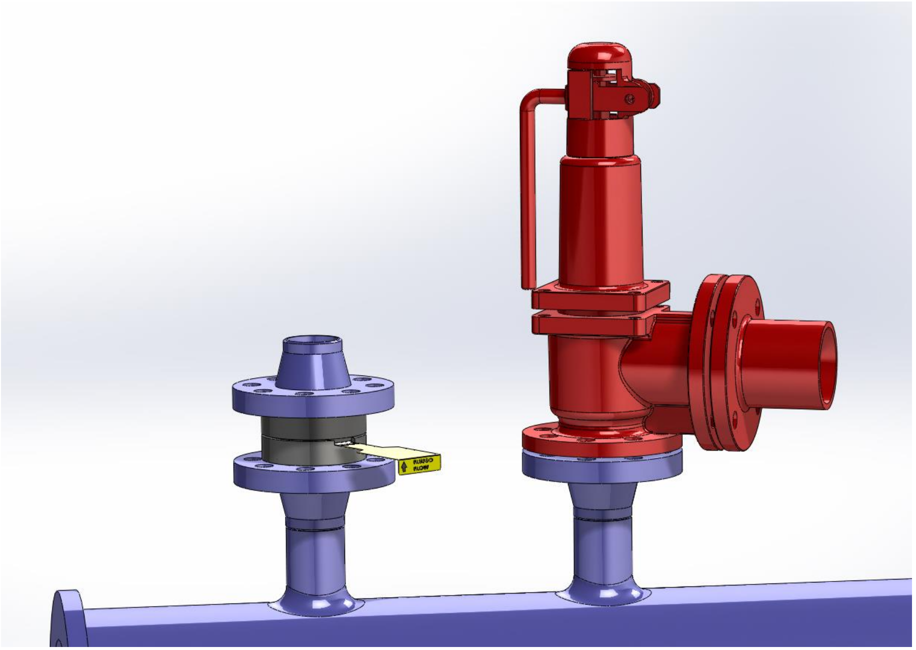
- 32 inspections included a pre-test. The results of some valves were:
  - 3 PSV's opened at a pressure higher than 110% of the set pressure, that means 9%
  - 6 PSV's opened at less than 90% of the set pressure, that means 19%
  - One thermal expansion cooling water PSV opened at 300% of the set pressure

Rupture Discs in combination with PSV

- RD represent both an alternative and a complement to PSV.
- RD may be installed in parallel, downstream or upstream a PSV

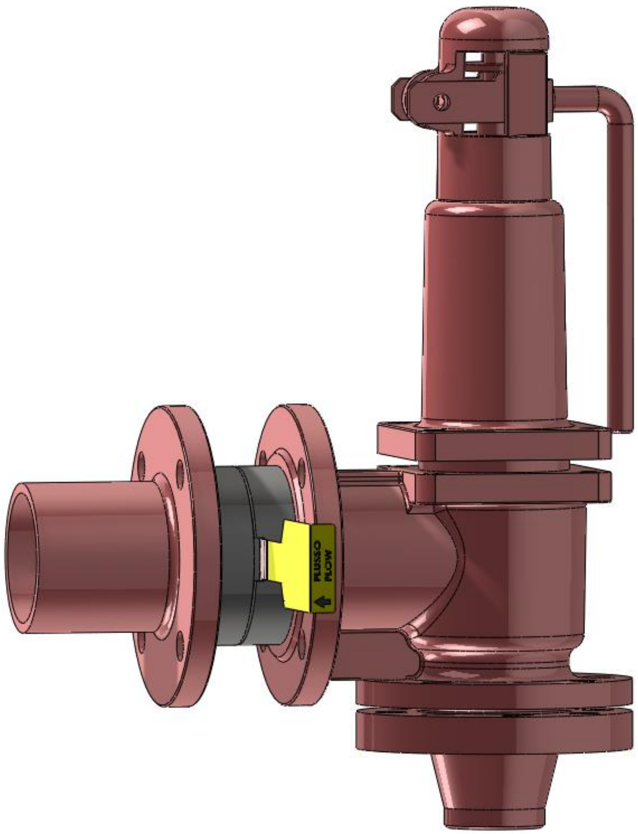
Rupture Discs in parallel with PSV

- Installation in parallel is useful for ensuring an additional protection level for the same or different plant failure case
- Typical application: protection of liquefied gas tanks



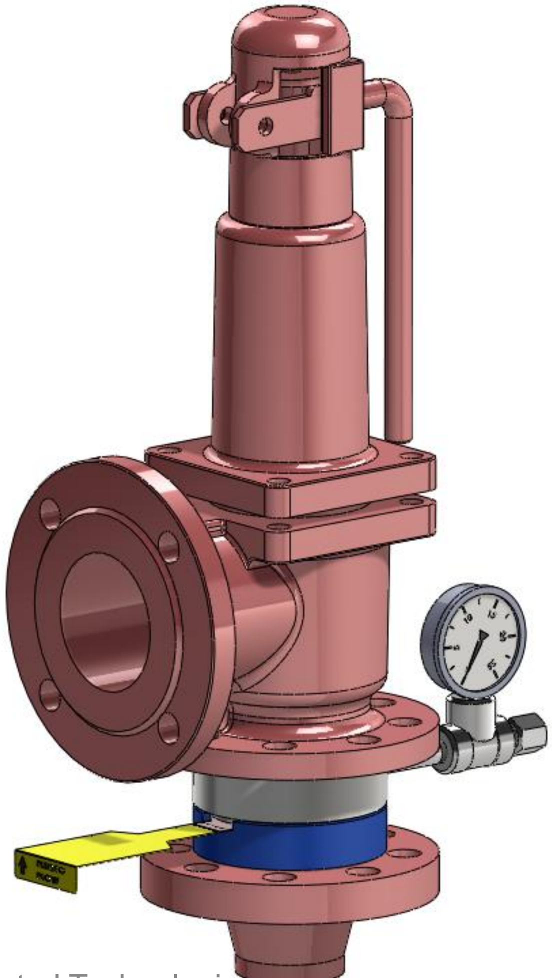
Rupture Discs downstream a PSV

- Installation of rupture discs downstream a safety valve is useful for protecting the valve from corrosive fluids that may be present in the discharge piping



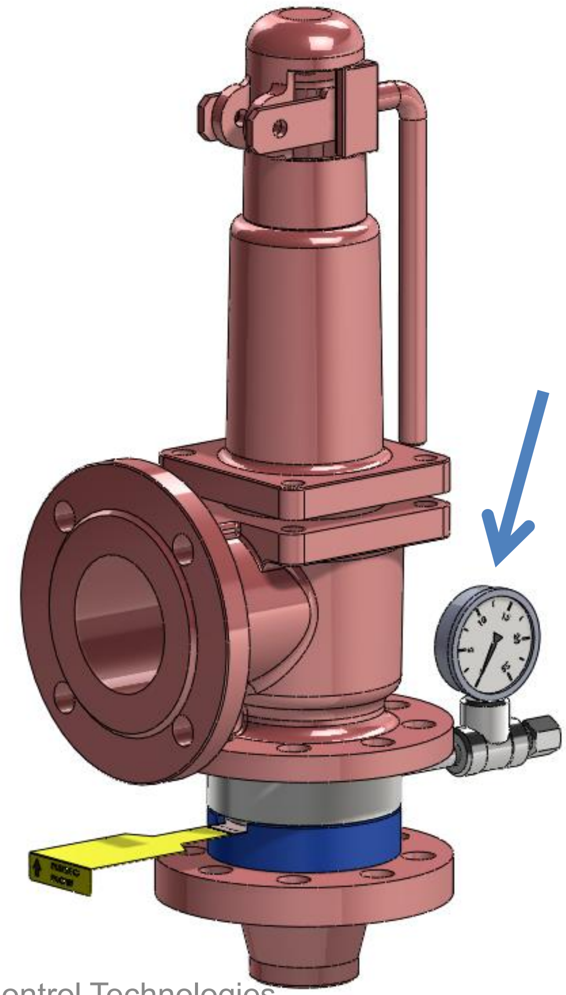
Rupture Discs upstream a PSV

- Installation of a RD upstream a PSV allows to combine the advantages of both devices, especially tightness of RD and re-closure of PSV
- RD isolates the valve from process fluids protecting it from corrosion and fouling.
- In addition installation of a RD upstream a PSV avoids leaks through the seat



Installation of a Rupture Disc upstream a PSV

- The space between the bursting disc safety device and the safety valve shall be provided with a connection to prevent or detect any unacceptable build up in pressure because the bursting discs, being pressure-differential devices, would require a higher pressure in the protected equipment to burst if pressure builds up in the space between the bursting disc and the safety valve.



Installation of a Rupture Disc upstream a PSV

- After bursting:
  - the bursting disc petals shall not protrude into the valve inlet,
  - release of bursting disc material shall not impair the performance of the safety valve

Installation of a Rupture Disc upstream a PSV

- Sizing should take into account the “combination discharge capacity factor” *F*d
  - *F*d is the factor used to determine the discharge capacity of a safety valve when the safety valve is used in combination with a bursting disc safety device installed upstream of the safety valve; it is determined experimentally.
  - As an alternative to the experimental testing to determine *F*d, the use of a default combination discharge capacity factor of 0,9 is permitted.

Main advantages of this combination

- Protect the valve from corrosive or fouling fluids
- ***Avoid leaks due to corrosion or fouling of the seat*** (very important for dangerous fluids))
- Reduction of valve maintenance costs (cleaning and calibration)
- Reduction of manufacturing cost of the valve that may be fabricated with less expensive materials
- Test the correct operation of the valve without dismantling the valve

Guidance and Standards

- Guidance and Standards to set the testing and maintenance requirements of PSV are based on evaluation of risk and type of service.
- If the service is “clean” (i.e. the valve is not in contact with fouling and corrosive fluids) the test/maintenance interval may be increased
- If the valve may come in contact with corrosive or fouling fluids maintenance intervals must be shortened

Maintenance interval guidelines

- Maintenance intervals of PSV in “clean” service may be set at 3 – 5 years
- Maintenance intervals of PSV in “dirty” service (corrosive or fouling fluids) should be reduced to 1 year or less
- Maintenance intervals of PSV protected with RD may be extended to the same level of PSV operating in “clean” conditions.
- This means increasing maintenance interval from 2 to 5 times
- A comprehensive approach to valve maintenance planning should take into account fouling, pre-test data results and inspection condition assessment.

Saving on Maintenance Costs

- Reduced valve maintenance cost obtained through increased maintenance intervals balances the cost of installation of a RD upstream a PSV

Total Ownership Cost

- All this information confirms that installation of a RD upstream a PSV allows the reduction of **Total Ownership Cost** by extending the life of the valve, allowing use of valves fabricated with less expensive materials, and reducing maintenance requirements.
- **Positive sealing is obtained**
- **The risk of fugitive emissions is reduced**

Summary

1. Overview of Rupture Disc (RD) and Pressure Safety Valves (PSV) design, fabrication, and performance.
2. RD represent both an alternative and a complement to PSV.
3. Pressure Safety Valves may leak through the seat especially
    1. If used for corrosive or fouling fluids.
    2. If used near the set point
    3. If maintenance is not adequate

Summary

4. Combination of RD and PSV: upstream, downstream and in parallel
5. Installation of a RD upstream a PSV isolates the valve from process fluids, protecting it from corrosion and fouling.
6. **In addition RD upstream a PSV avoids leaking**

Summary

7. Testing, inspection and maintenance of PSV at regular intervals are required in order to avoid that PSV may fail to open at set pressure.
8. **Cost of installation of a RD upstream is balanced by reduction of valve maintenance cost**

We have also seen

- Selection and sizing criteria
- Coupling requirements
- Other combinations of safety valves and rupture discs like
  - installation in parallel in order to ensure an additional protection level and
  - installation of rupture discs downstream a safety valve in order to protect the valve from fluids that may be present in the discharge piping

Additional information

- Additional information is available in the full paper included inthe conference proceedings
- More details and explanations are available from

- Internat site : www.donadonsdd.com
- Or direct enquiry

Thank you for your attention

Questions ?