Gasoline Spray Session

Session Organizer: Scott E. Parrish, General Motors R&D

One outcome of the first ECN workshop was the decision to form a gasoline spray working group. This group has formed and has had some activities since ECN1 including two WebEx meetings and an informal meeting at the 2012 SAE world Congress. The primary focus of the group thus far has been to determine an appropriate injector specification and to identify an injector supplier able to meet the needs of the group.

It is intended that the findings of the group will be transferable and relevant to *future advanced* engines. Therefore in specifying an injector it is important to keep in mind the spray requirements of advanced applications such as stratified spray-guided and down size boosted diluted combustion systems. The interaction of adjacent spray plumes is of great importance to both current and advanced gasoline applications. Factors that affect spray plume interaction include: spray pattern, L/D ratio, hole manufacturing method, and the proximity of the holes on the nozzle. The proper combination of all of these parameters is required for successful mixture preparation.

After considerable debate the following injector specification was selected: solenoid actuated, 80 degree spray angle, 8-hole, circular pattern, stepped hole VCO, no bend angle, straight EDM holes, and a flow rate of 15 cc/s @ 10 MPa fuel pressure.

The needs from the injector supplier have been identified and include: 12 injectors and 6 injector drivers along with 6 simplified wiring harnesses. The supplier must also agree to allow detailed geometric measurements and to supply a CAD model of the injector nozzle to support internal flow modeling activities. Four injector suppliers (Bosch, Continental, Delphi, and Magneti Marelli) were solicited and all expressed interest in participating. After considerable contemplation, Delphi was the supplier selected do to the fact that they were willing to accommodate nearly all the desires of the group. The selection of Delphi is NOT an endorsement or an indication of hardware superiority but rather more to do with convenience.

The majority of the session was devoted to the presentation of hardware details. In addition to injectors and injector drivers, Delphi will be providing provisions to mount the injector and to attach a fuel line. These parts will include a cast rail socket and a fastening clip. Details of each part were discussed and critical dimensions were presented. Pictures and drawings facilitated the discussion. A solid model of the nozzle seat was shown and a CAD model will be available to the group upon the nozzle design being finalized. Spray patternation results of an 8-hole development nozzle were shown and exhibited good symmetry.

In preparation for performing measurements, experimental conditions were discussed and the following conditions were proposed. Fluid, Iso-Octane; injection pressure, 20MPa; fuel temperature, 90 C; ambient pressure, 6 bar; ambient temperature, 300 C; and injected mass, 10 mg.

ECN2: Gasoline Spray Session

Session organizer:
Scott E. Parrish

Second Workshop of the Engine Combustion Network,

Heidelberg, Germany, September 2012

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Introduction and Background

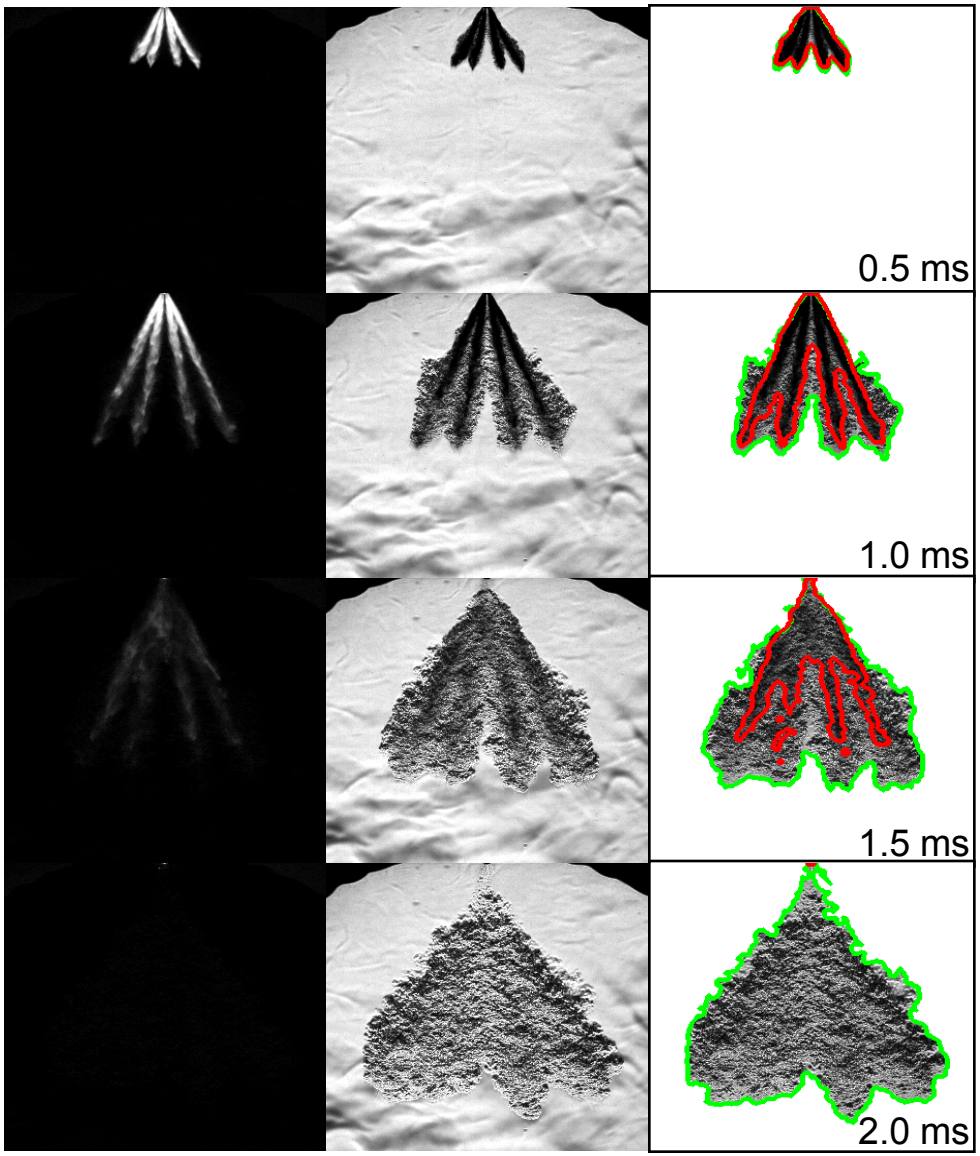
- Activities of the Gasoline Spray ECN
  - 14 May, 2011 (ECN1)
    - Initial discussion and decision to form a Gasoline Spray ECN group
  - 29 September, 2011 (First WebEx™ meeting of Gasoline Spray ECN group)
    - Identify injector type and discuss injector specification
    - Discuss hardware needs and requirements of potential suppliers

      Action item: Inform and solicit potential injector suppliers
  - 26 January, 2012 (ECN1.5 WebEx™)
    - Finalize injector specification
    - Begin discussion of operating conditions
  - 25 April, 2012 (Informal update during SAE congress)
    - Provide status of injector supplier response

Injector specification

- Considerations for injector specification
  - Hopefully the output of the group will be transferable and relevant to *future advanced* engine implementations
  - It is important to keep in mind the spray requirements of advanced applications such as stratified spray-guided, HCCI and boosted dilute systems
  - The interaction between adjacent spray plumes is of great importance to both current production and advanced gasoline applications
  - Spray plume interaction is influenced by a number of things including:
    - spray pattern
    - L/D ratio
    - hole manufacturing method
    - proximity of the holes on the nozzle
  - Successful mixture preparation relies on a proper combination of all these parameters

Injector specification – Plume interaction



Mie Schlieren Overlay

(10mg_90C_20MPa_500K_500kPa)

Injector specification

Parameter	Consensus 9/28/2011	Final Specification 1/26/2012
• Number of holes	6-8	8
• Spray shape	circular	circular
• Spray angle	60°-80°	80°
• Bend angle	0 °	0°
• L/D ratio	1.0-2.0	2.0
• Hole shape	straight	straight
• Manufacturing	EDM or Laser machined	EDM
• Flow rate	15-20 cc/s @ 10 MPa	15 cc/s @ 10 MPa

Supplier solicitation and selection

- Needs from the injector supplier
  - 12 state-of-the-art injectors
  - 6 stand alone injector drivers that require only a supply voltage (12-14 V) and a control signal (TTL)
  - 6 simplified wiring harnesses
  - Supplier must be willing to allow detailed geometric measurements of the injectors
  - CAD model of injector nozzle and valve seat area for internal flow modeling
- Injector suppliers solicited
  - Bosch, Magneti Marelli, Continental, Delphi
- Supplier Selection
  - Selection was based on meeting the above stated needs
    - Selection is **NOT** an indication of hardware superiority

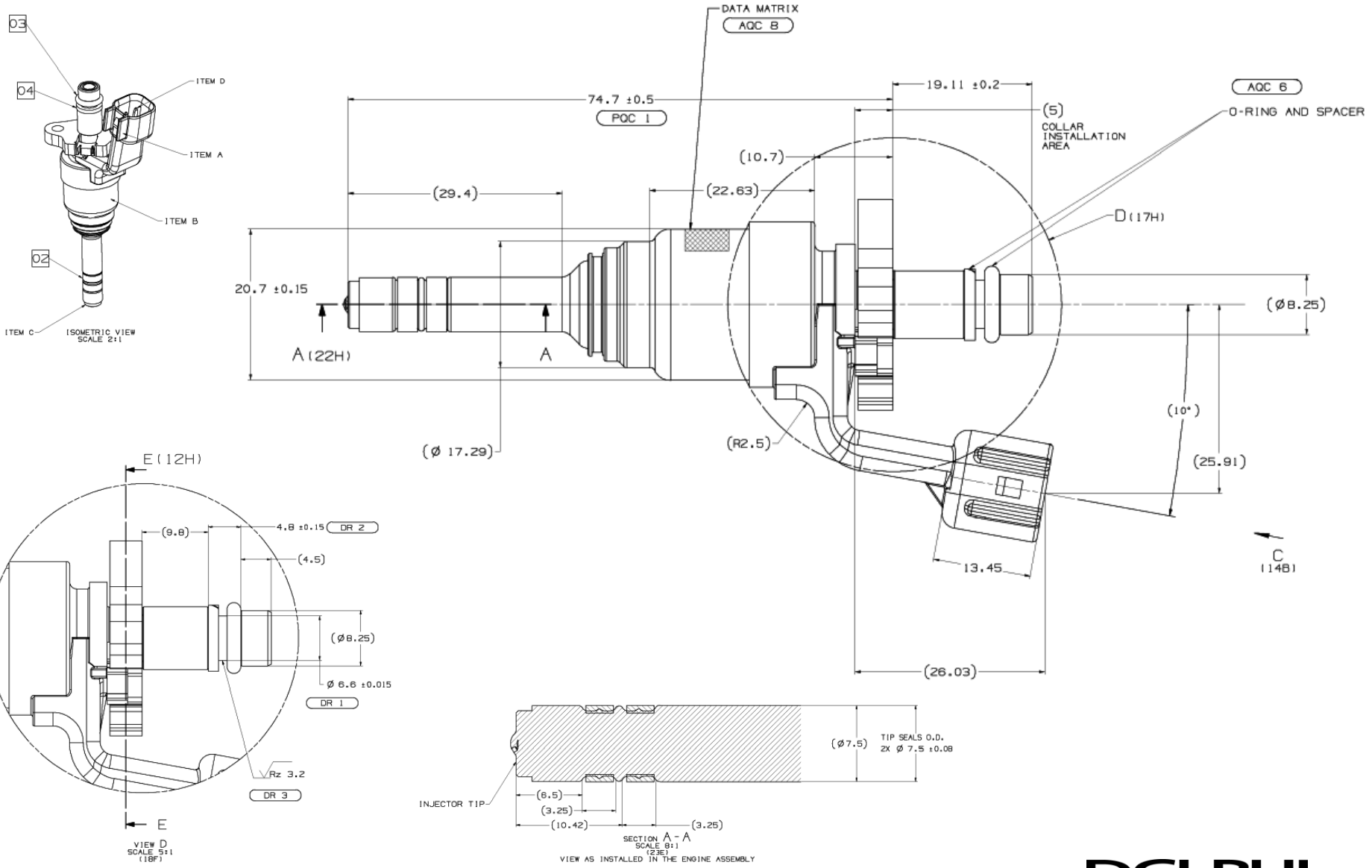
Supplier solicitation and selection

- Delphi was the most accommodating supplier
- Parts to be supplied by Delphi
  - 12 Injectors (with all necessary seals)
  - 6 Cast rail sockets (¼" OD)
  - 6 Fastening clips
  - 6 Isolation grommets and mounting bolts
  - 6 Injector drivers (with multiple waveforms)
  - 6 Simplified wiring harness

  (Anticipated distribution of hardware to ECN members – November)
- CAD model of nozzle / valve seat area will be provided

  (Immediately available but final nozzle configuration is still under development)

Hardware details - Injector dimensions



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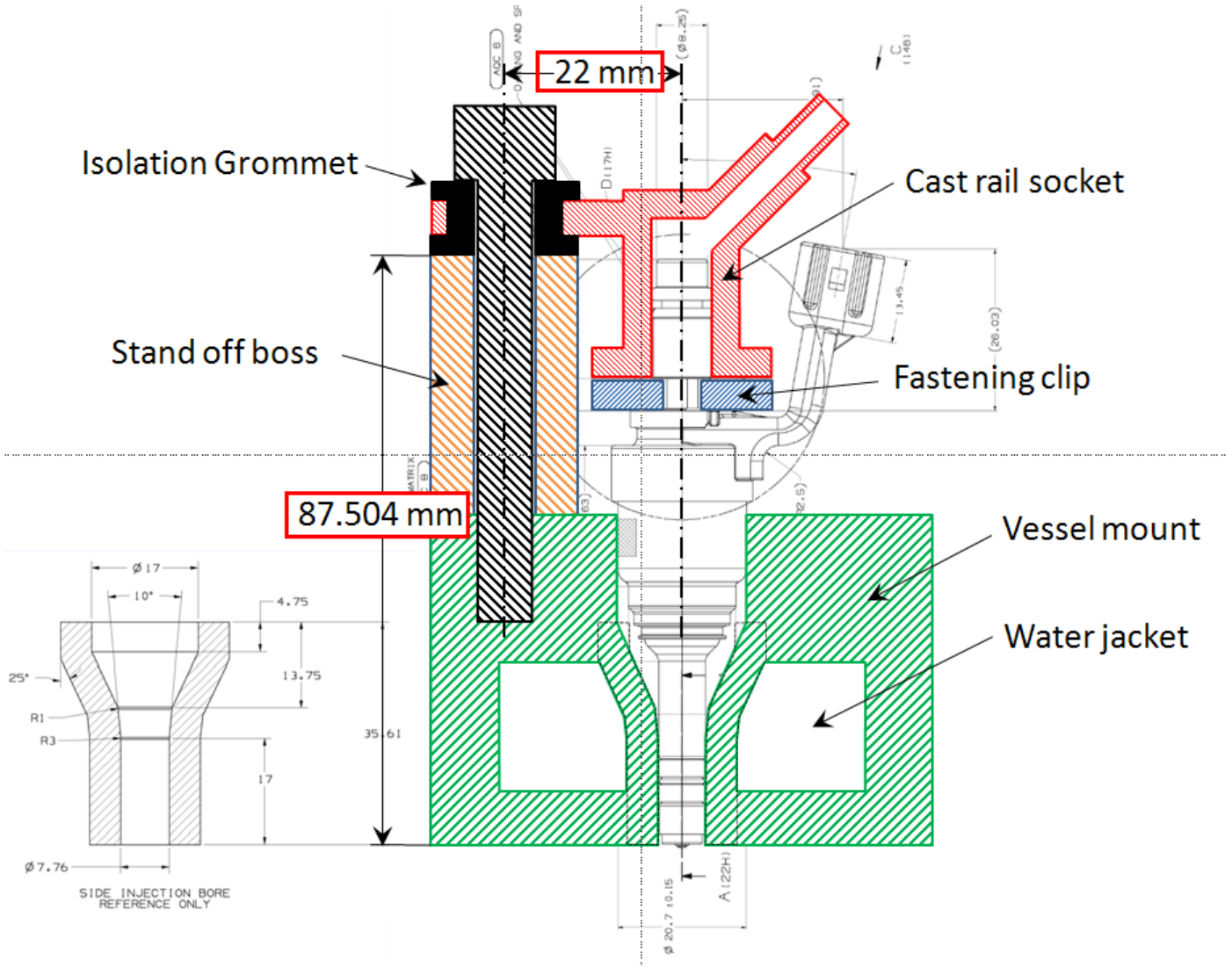
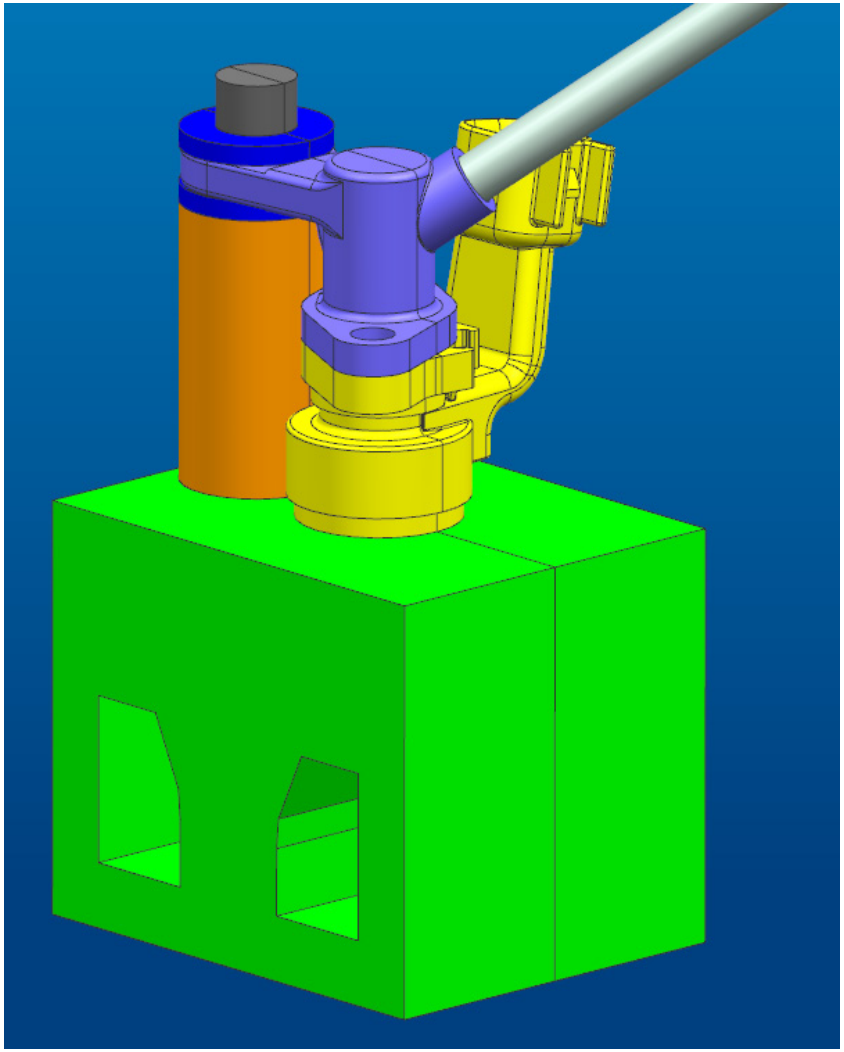
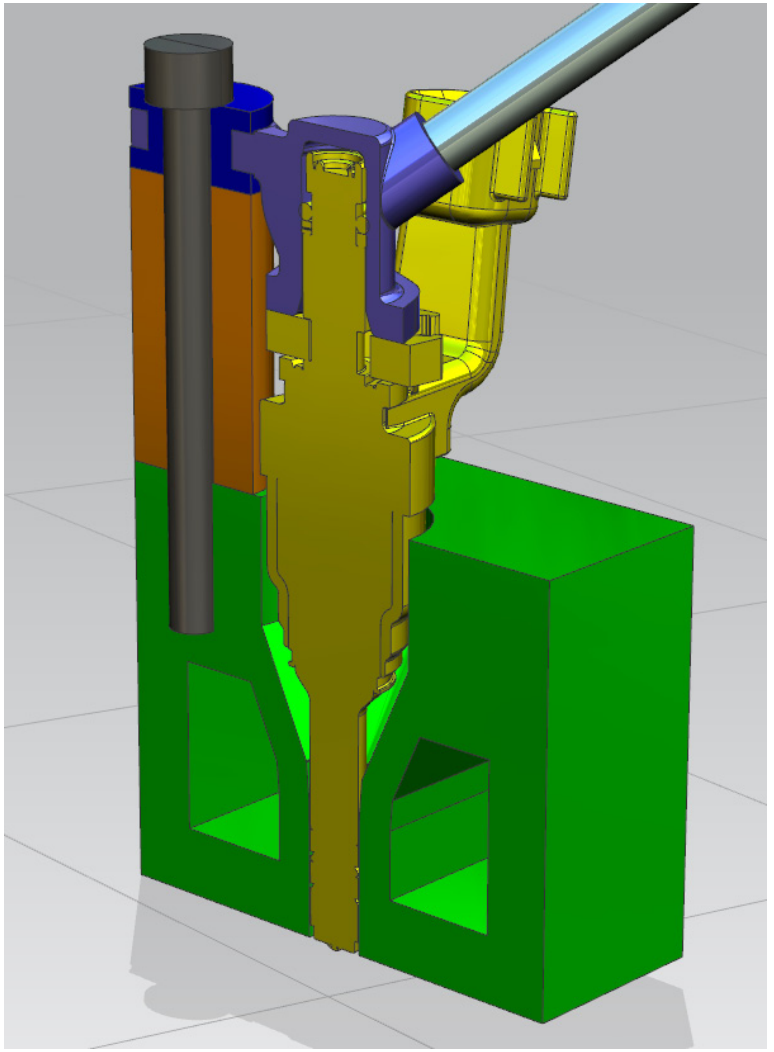
Hardware details - Injector mounting specifics



Hardware details - Injector mounting specifics





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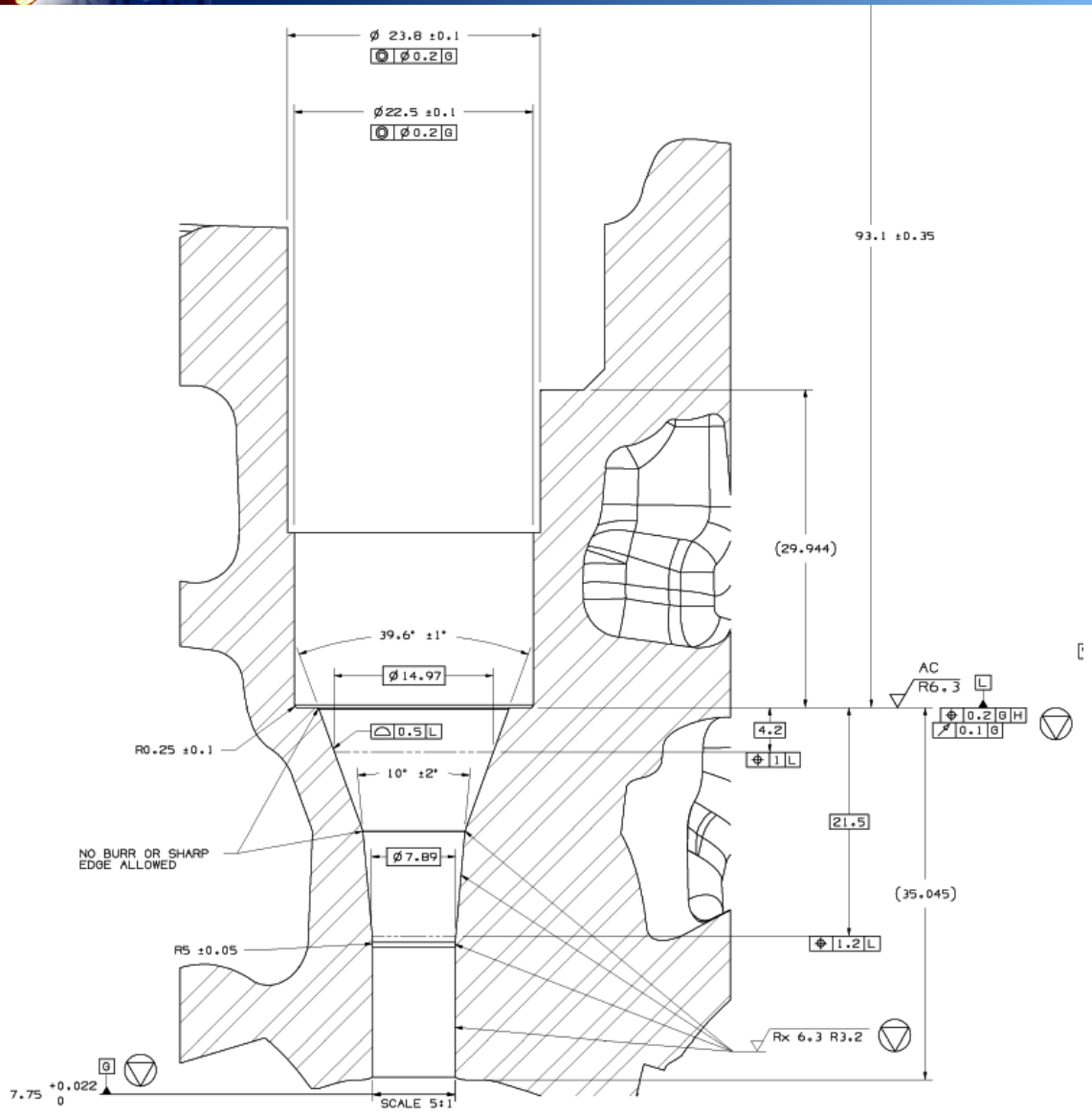
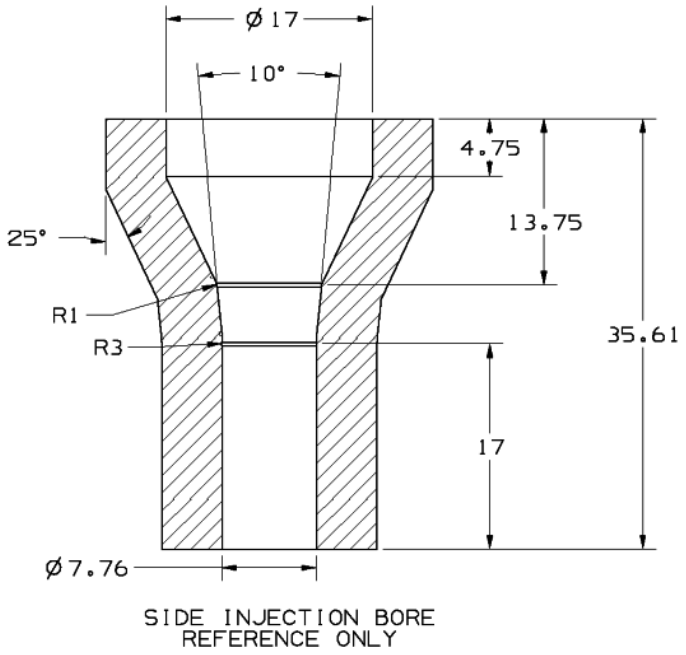
Hardware details - Injector pocket dimensions



Simplified Detail



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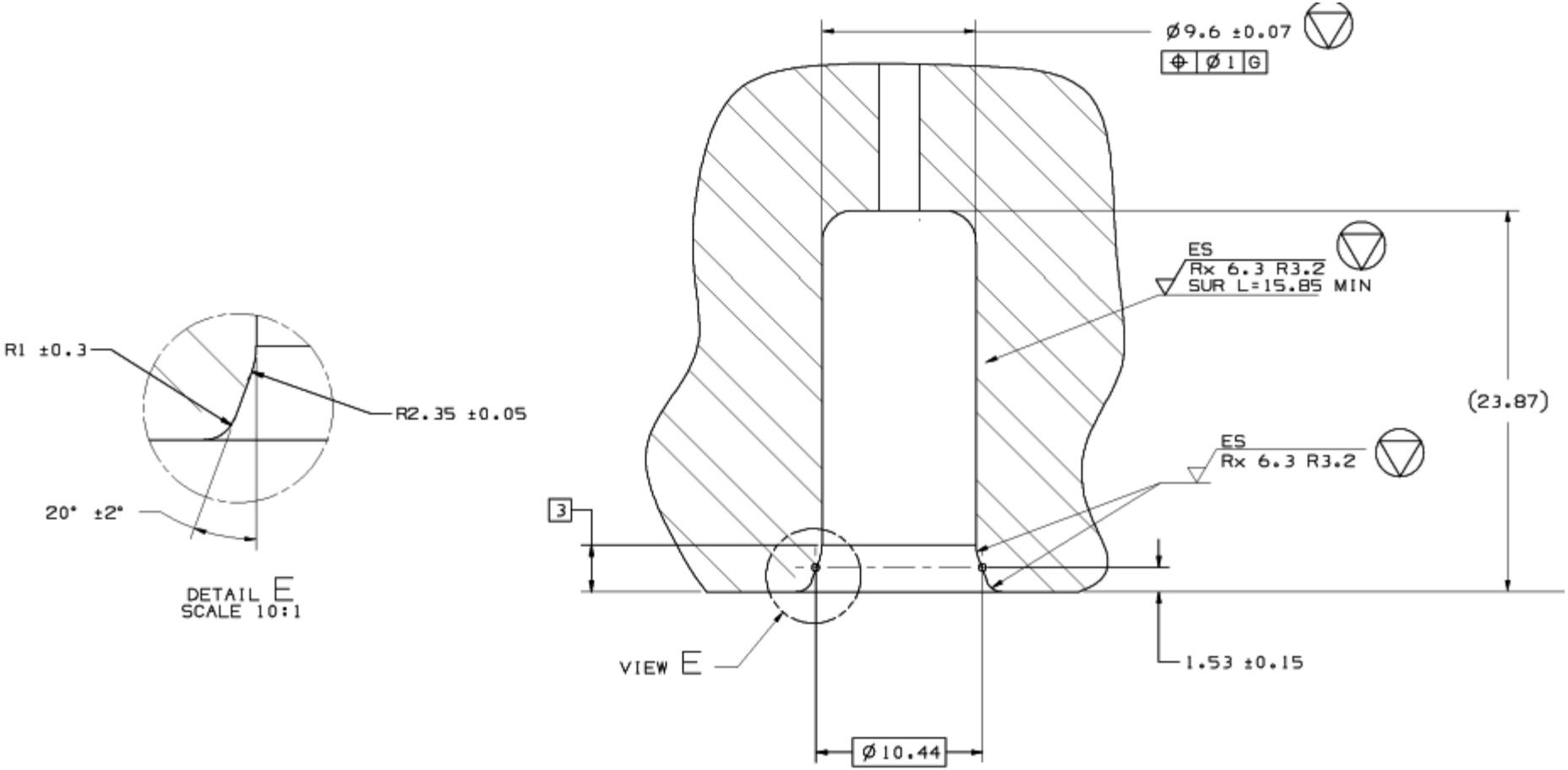
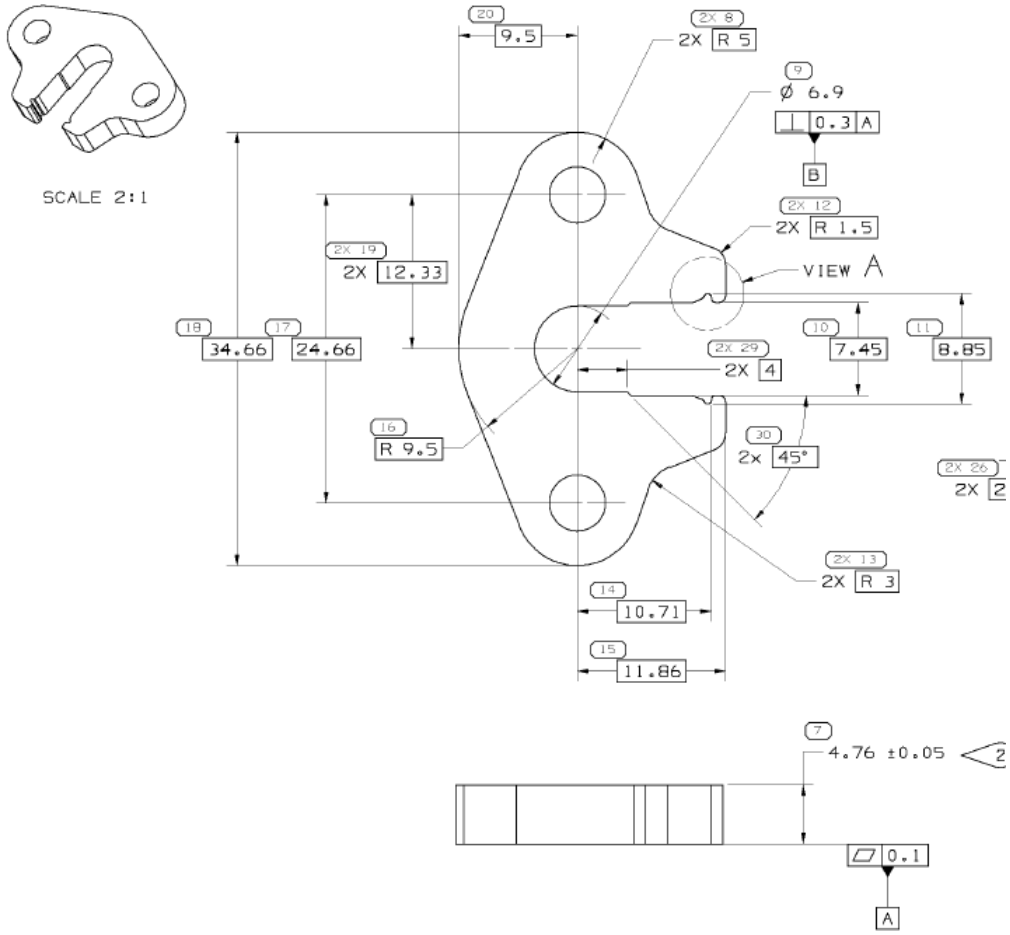
Hardware details - Rail socket dimensions



Hardware details - Fastening clip dimensions



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Hardware details - Injector assembly

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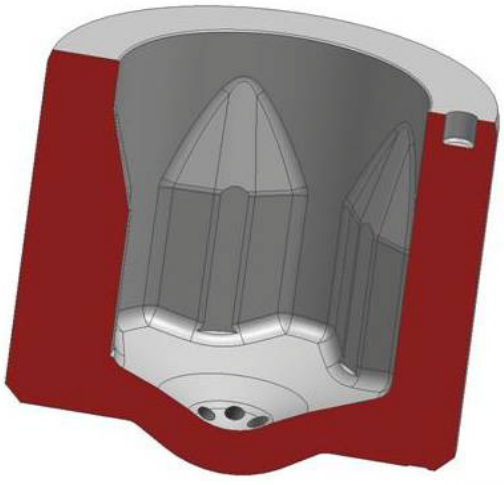
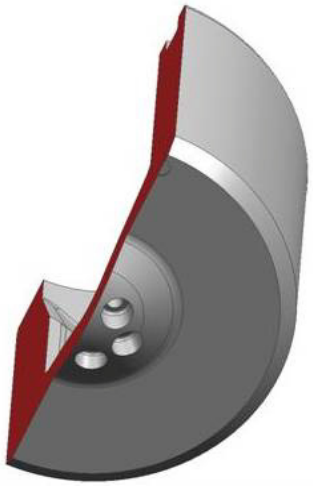
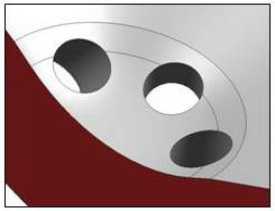
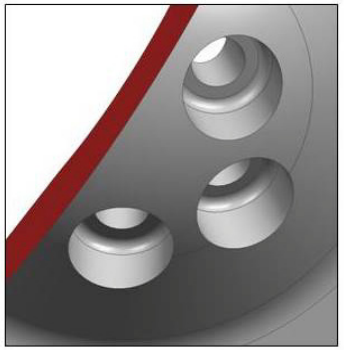
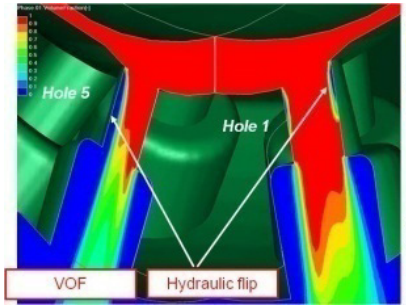
Hardware details – Nozzle Details

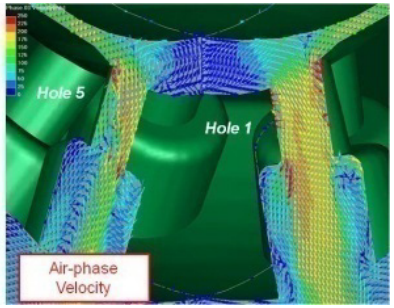


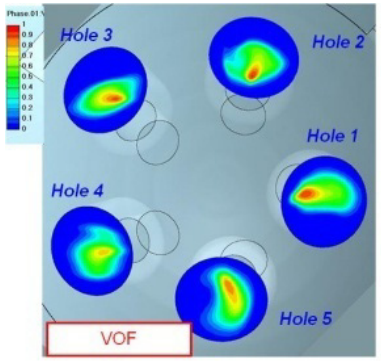


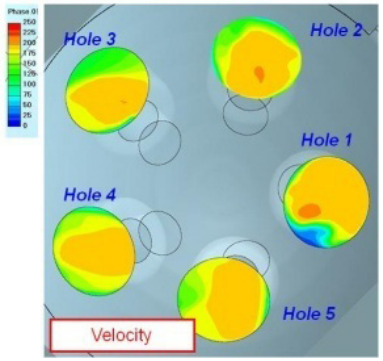












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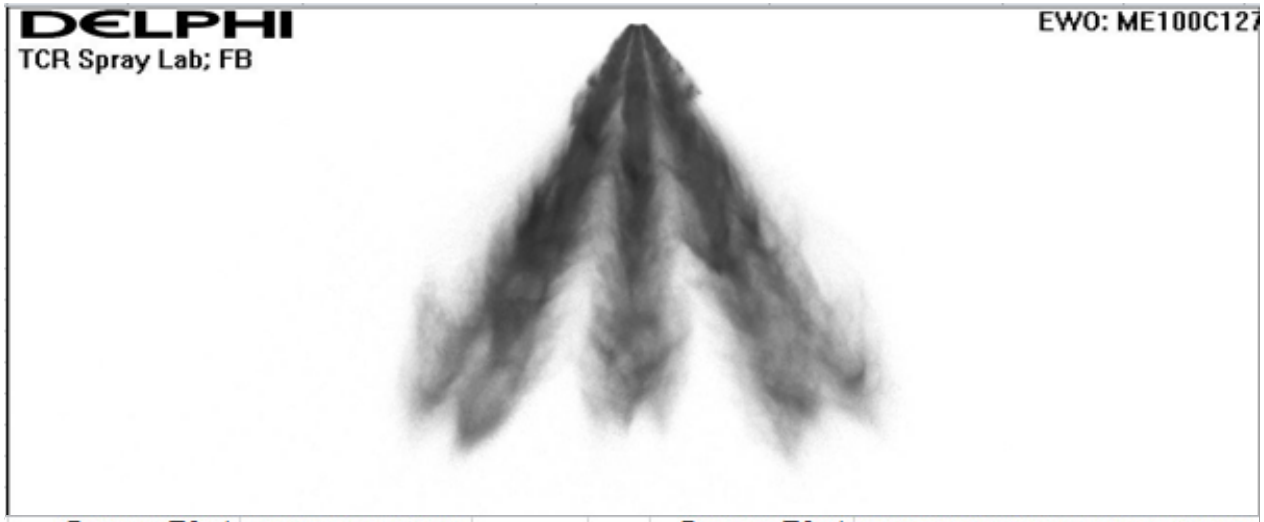
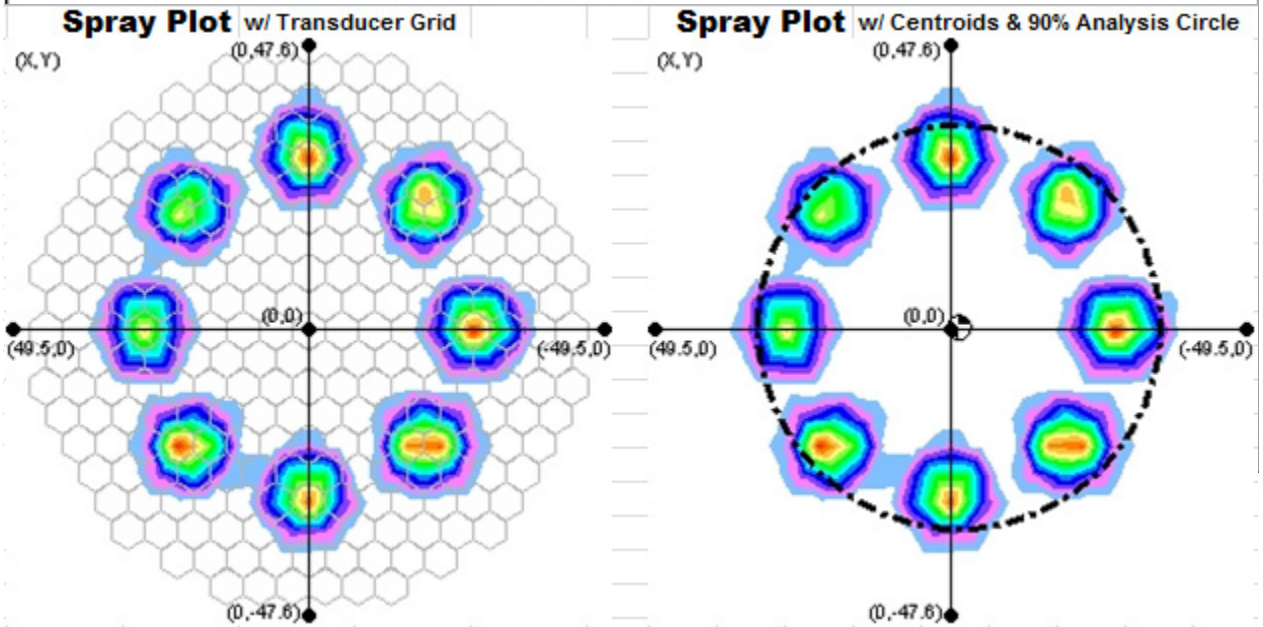
Hardware details - ECN nozzle development





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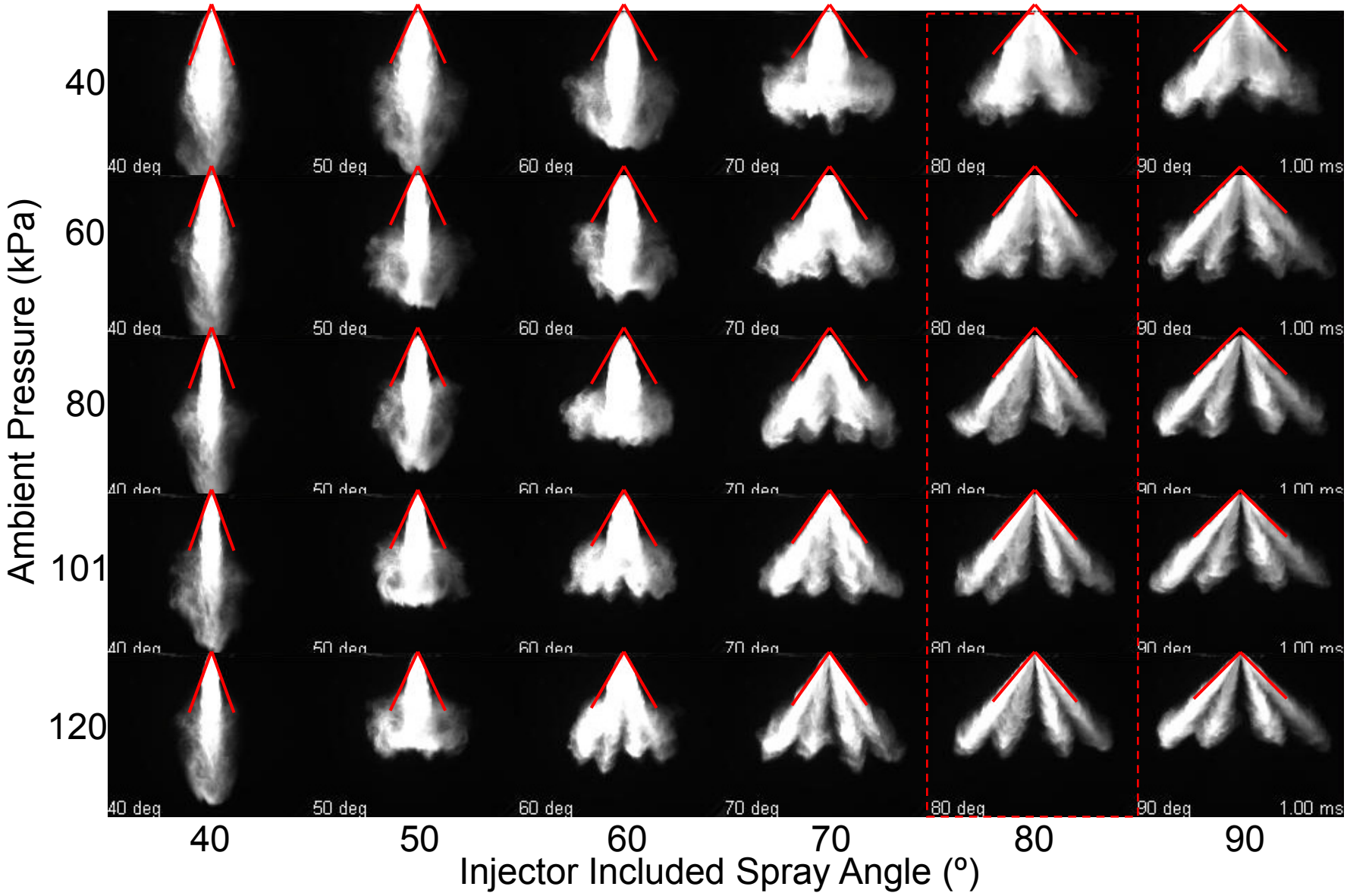
Experimental Conditions - Considerations

- Considerations for choosing operating conditions
  - Operating conditions of gasoline engines vary widely
  - Most all current production engines operate with early injection where sprays can be subjected to low pressures resulting in flash boiling
  - Most advanced engine concepts rely on late injection where sprays are subjected to elevated ambient pressures and temperatures
  - What conditions should be pursued?
  - What institutions are capable of conducting spray measurements with ambient pressure below atmospheric?

Effects of low ambient pressure (flash boiling)



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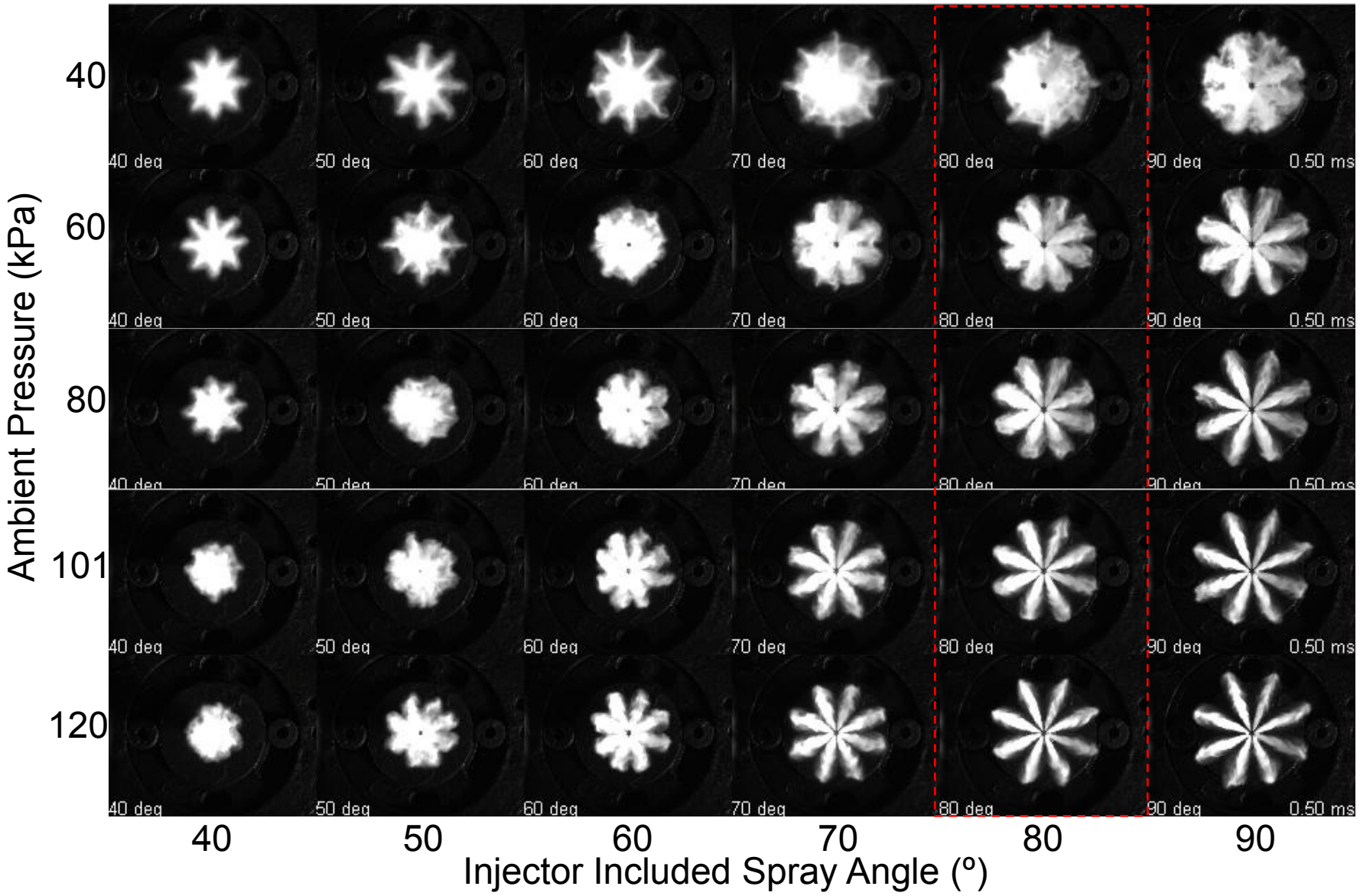

Experimental Conditions – Suggestion

Parameter	Suggestion	
• fuel	Iso-Octane	
• fuel pressure	20 MPa	
• fuel temperature	90º C	
• injector temperature	90º C	
• ambient pressure	6 bar	60 kPa
• ambient temperature	300º C	20º C
• injected quantity	10 mg	
• number of injections	1	

Discussion Period

Discussion Period