Eaton Corporation
Vehicle Group-Materials CoE
19218 B Drive South
Marshall, Michigan 49068
269/781-0200

Materials and Basic Processes Report

MAT #	**21279_07515**
Prepared By	E. Vincent
Work Done By	D. Osborne
Date	13 Oct. 2021
Pages	1 of 5

Background:

Ford returned 1 intake valve (P/N 372237) fractured thru the 3rd keeper groove. The valve was in the intake cylinder #5 position from VIN# 2FMPK4AP5[redacted] with 388miles. The valve was returned from the Capital Ford dealership. The intake valve date code is 21-C-1.

Objective:

1. Document tip contact, OD, and keeper groove.
2. Analyze fracture surface and document crack initiation site and fracture mode.
3. Perform Ford microhardness profile on a longitudinal tip section.
4. Document surface and core microstructure at the fracture.

Findings:

1. The valve tip fractured in the third keeper groove via fatigue initiating at the keeper groove surface and propagating unidirectionally across ~90% of the tip cross-section. The tip chamfer exhibits contact damage coincident with the crack initiation.
2. The valve tip exhibits a typical hardness profile for induction hardened EMS-322. The average tip hardness at the core is 55 HRC converted from HV0.5. The average hardness at the left and right keeper grooves is 57&56 HRC respectively converted from HV0.5.
3. The valve tip microstructure consists of tempered martensite at the surface and core consistent for hardened and tempered EMS-322. The keeper groove surface shows evidence of grinder burn at the fracture location.

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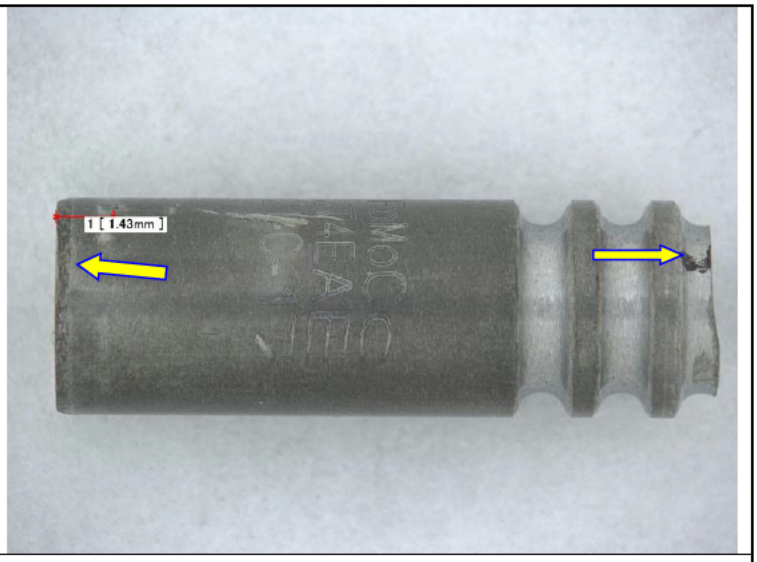
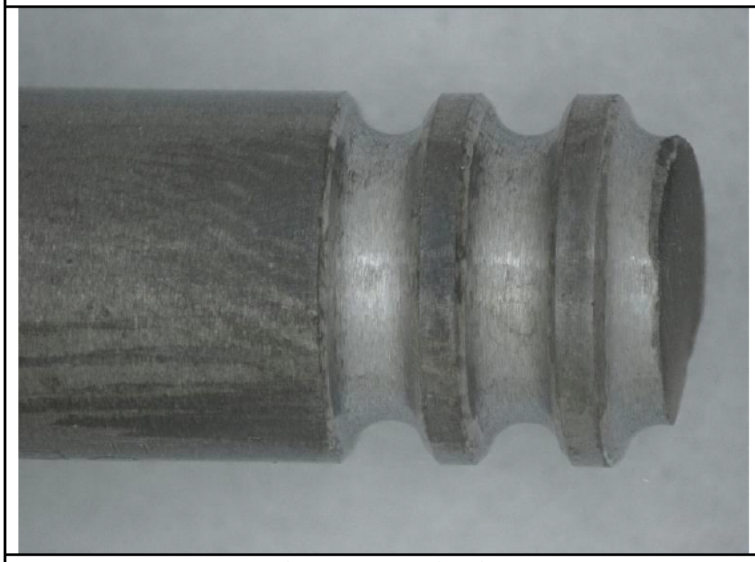
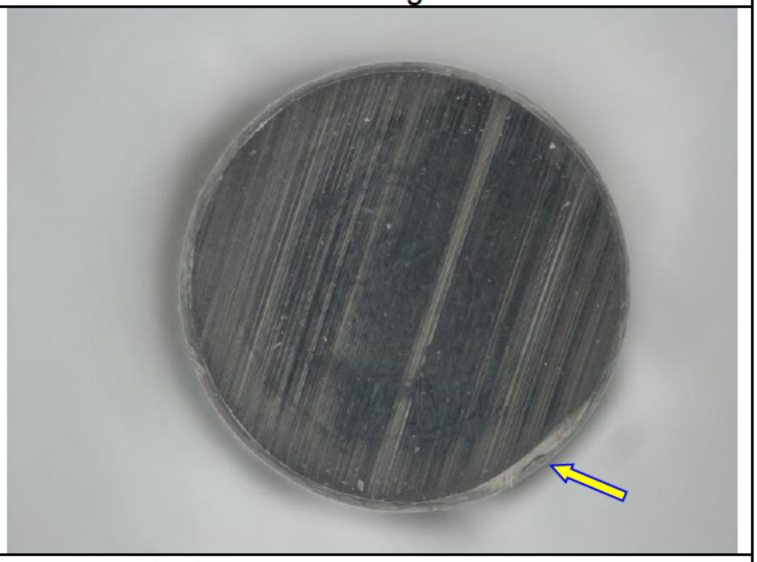
a) Fracture Surface



b) Tip OD date code 21-C-1, arrows show orientation of chamfer damage and crack initiation



c) Keeper groove, typical contact



d) Tip contact, chamfer damage

Figure 1: Macro photographs of the intake valve tip fracture. The valve tip fractured in the third keeper groove via fatigue initiating at the keeper groove surface and propagating unidirectionally across ~90% of the tip cross-section. The tip chamfer exhibits contact damage coincident with the crack initiation.

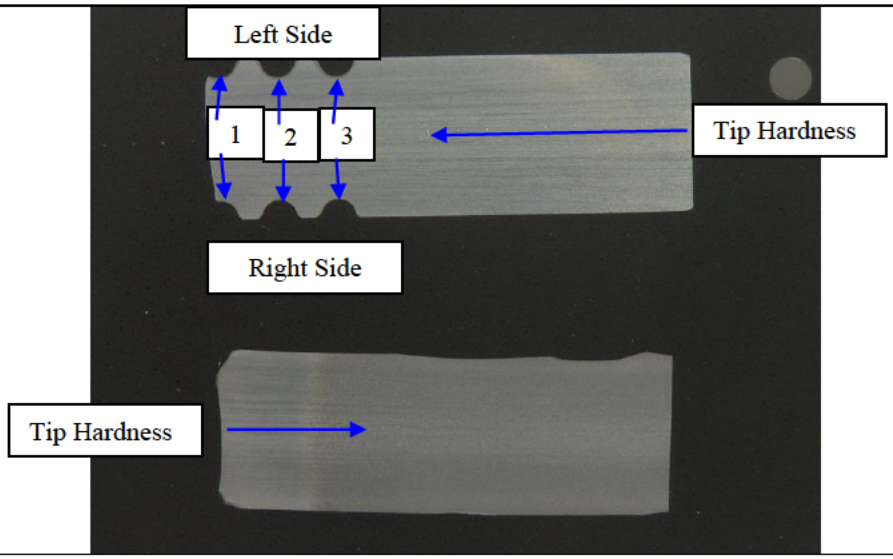


Figure 2: Macro photograph of a representative longitudinal tip section showing the hardness profile locations.

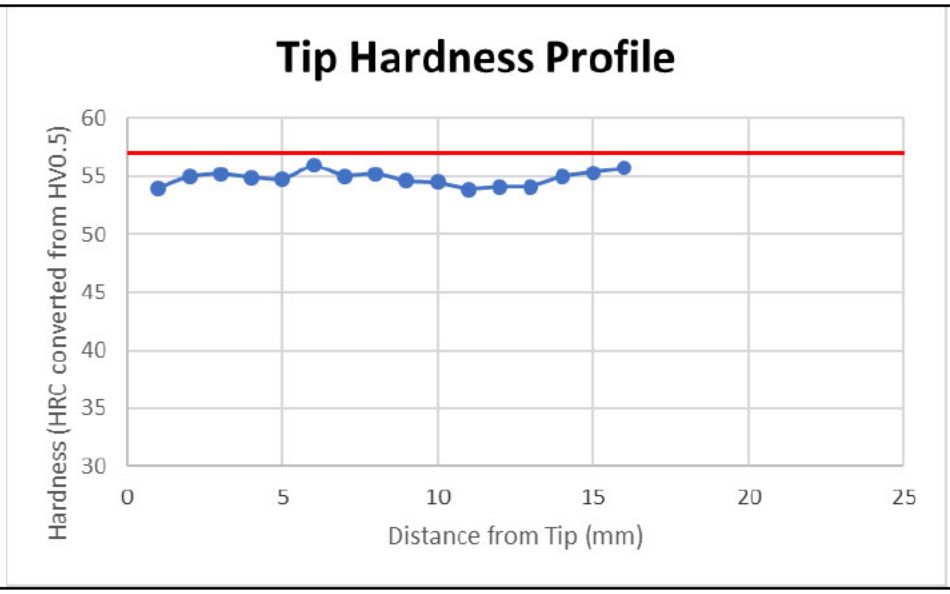


Figure 3: Tip hardness profile measured HV0.5 and converted to HRC. The valve tips exhibit a typical induction hardened profile.

Table 1: Microhardness measurements on the left and right keeper groove cross-sections measured HV0.5 and converted to HRC. The left and right keeper grooves exhibit typical hardness values.

	Left Side	Right Side
KG 1	56.5	55.5
KG 2	55.6	56.3
KG 3	57.7	56.3

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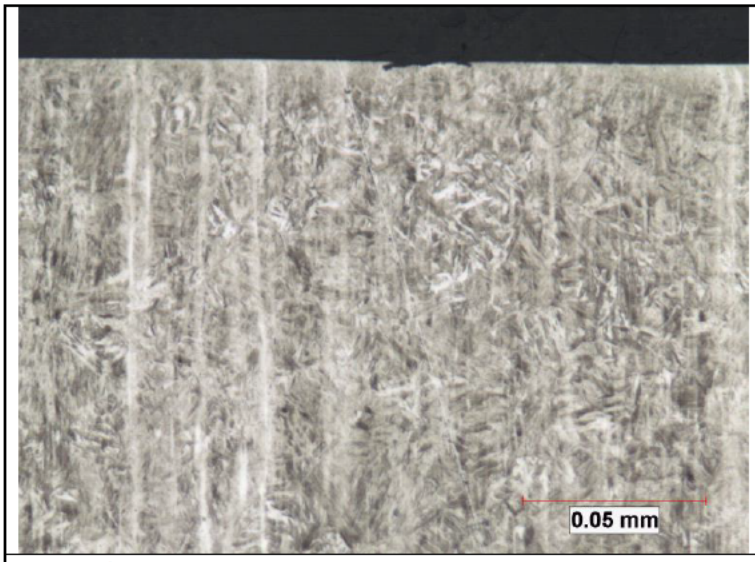
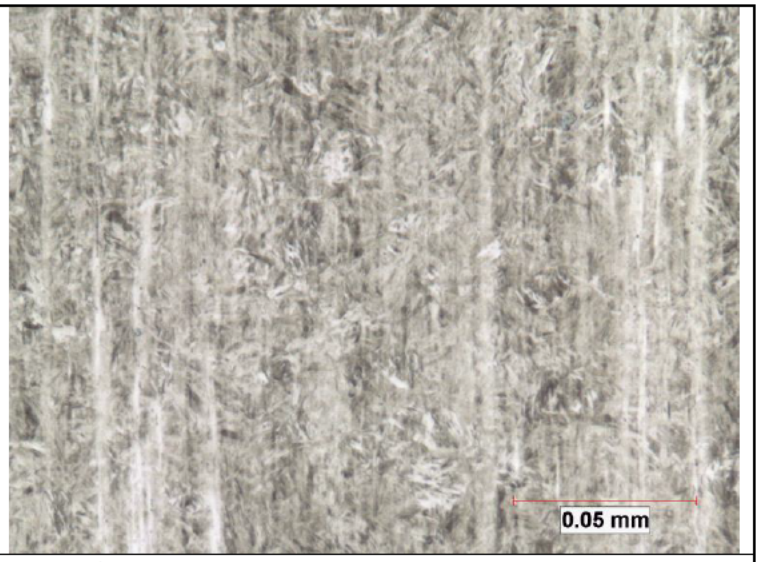
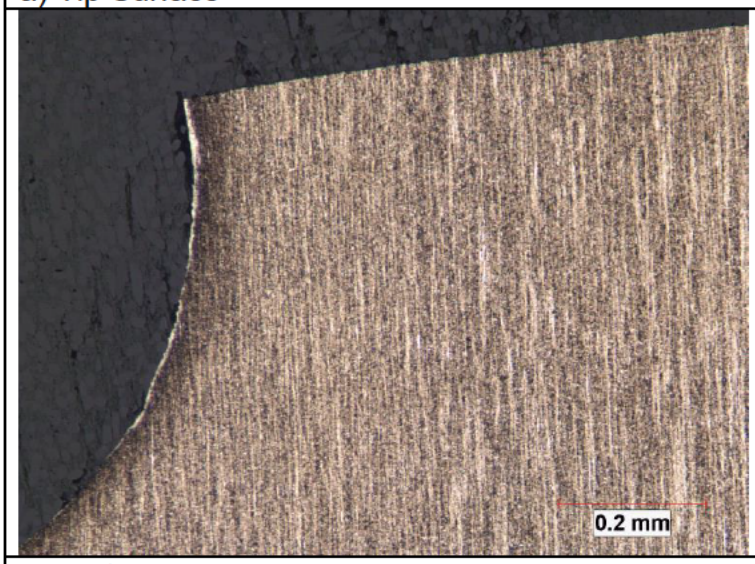


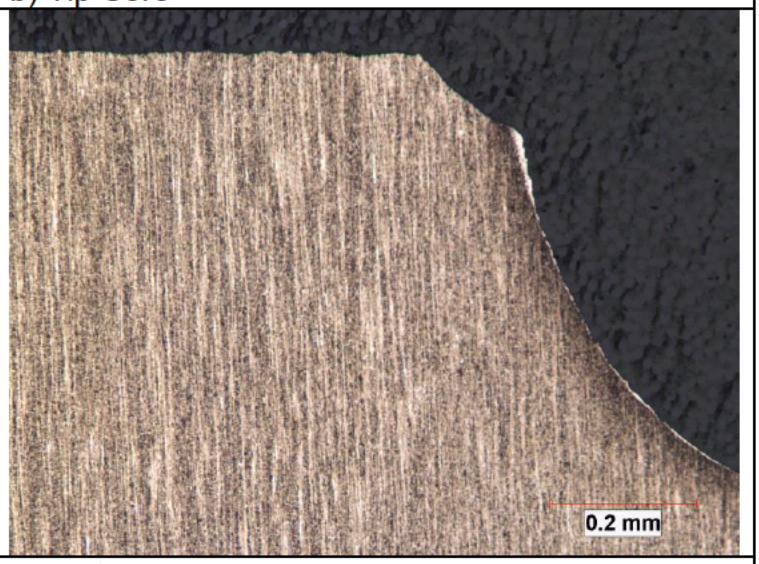
2% Nital 500X
a) Tip Surface



2% Nital 500X
b) Tip Core



2% Nital 100X
c) Fracture origin at the keeper groove



2% Nital 100X
d) Final fracture at the keeper groove

Figure 4: Etched micrographs on the longitudinal section thru the fractured valve tip. The valve tip microstructure consists of tempered martensite at the surface and core consistent for hardened and tempered EMS-322. The keeper groove surface shows evidence of grinder burn at the fracture location.