ENGINEERING BULLETIN

Bulletin No. 12.14.17

SAFETY ALERT

Brake Pad Failure Modes and their Consequences

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EFFECTIVE - DECEMBER 14, 2017

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1. Introduction

As is sometimes the case, there is far more to visible or apparent corrosion than meets the eye. In the case of brakes, red rust on a rotor surface that is visible through your wheel is just the tip of the iceberg. This visible layer of rust may even be easily wiped away by applying the brakes a few times while driving. On the other hand, the effects of that same rust-producing environment on the brake pads (that you cannot see) in the same wheel is advanced corrosion that is progressively deteriorating and rotting with rust, creating separation between the brake friction pad and the brake system.

It has also been observed that a high number of pads are being replaced significantly before the friction lining has been worn to a replacement level.

These concerning observations have together provided the basis to launch a systematic brake-field study described below.

The study also provides an opportunity to share field-use observations related to brake friction pad rust and its direct impact on vehicle safety, so to provide awareness to the industry and consumers.

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2. Materials and Method

The brake field-study involves the examination of brake pads replaced at garages in two dissimilar market-driving conditions: (i) Toronto, Ontario, Canada, classified as snow-bound, salted, and harsh; and, (ii) Houston, Texas, USA, classified as humid and sub-tropical.

The collection of the replaced brake pads across months – and numbering more than 3200 parts– was designed to include the impact of the four seasons. The brake pads were received in crates on wooden skids at Nucap's R&D Lab in Toronto, Canada (Fig. 1).

FIG. 1
AS-RECEIVED BRAKE PADS

FIG. 2
TAGGED AS-RECEIVED BRAKE PADS

Each As-received Brake Pad was catalogued, tagged with a number designation, photo-documented, and visually inspected (Fig. 2).

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3. Observations, Failure modes and Immediate Safety Concerns

The brake pads were grouped into 5 different types of conditions for this category:

i) No apparent visible cause of Replacement

ii) Friction Worn to Backplate

iii) Excessive Rust **(a potential safety risk)**

iv) Pad Edge Lift **(direct implication on braking safety / braking confidence)**

v) Broken/Separated Friction **(direct implication on braking safety / braking confidence)**

i) No apparent visible cause for replacement (Fig.3)

FIG. 3

- **Noted in 66.9% of the cases**
- The majority of these brake pads showed more than 50% of friction life remaining with no visible delamination or separation

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ii) Friction Worn to Back-plate (Fig.4)

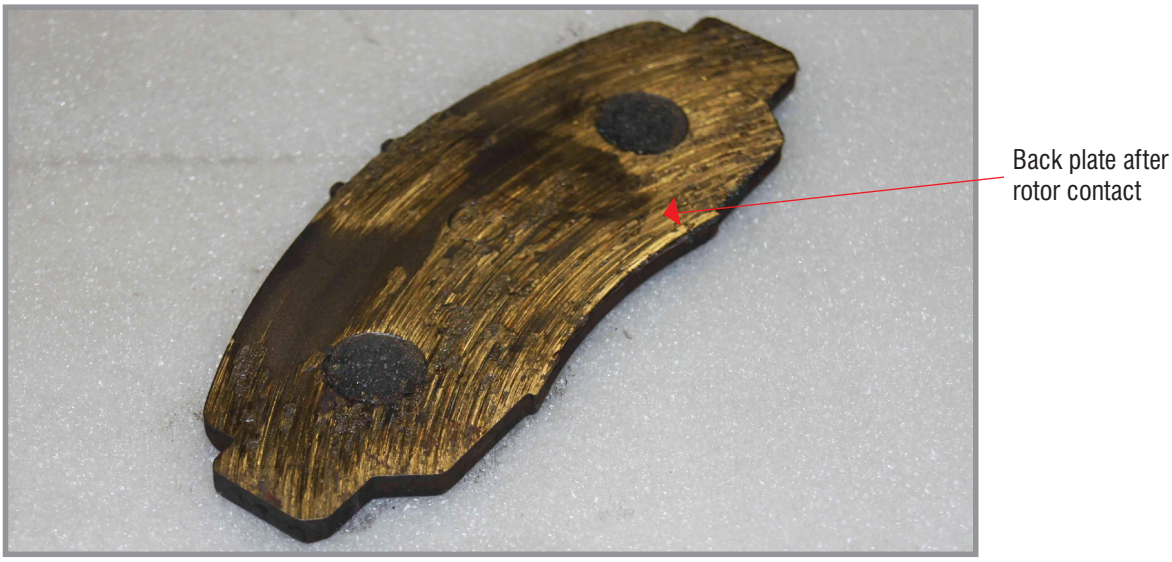

FIG. 4
FRICTION WORN TO BACK-PLATE

- **Noted in 5.6% of the cases (or 179 cases)**
- Complete wear-out to back-plate; evidence of galling
- **Consequence: Noise; rotor damage requiring replacement**

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iii) Excessive Rust (Fig. 5)

FIG. 5
EXCESSIVE RUST

- **Noted in 11.0% of the cases (or 352 cases)**
- Shim de-bonded; pad abutments and clips corroded
- **Consequence: Noise; drag, leading to early wear-out and increased fuel consumption; possible shim migration leading to cut brake rotor (a tangible safety risk)**

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iv) Pad Edge-lift (Fig. 6)

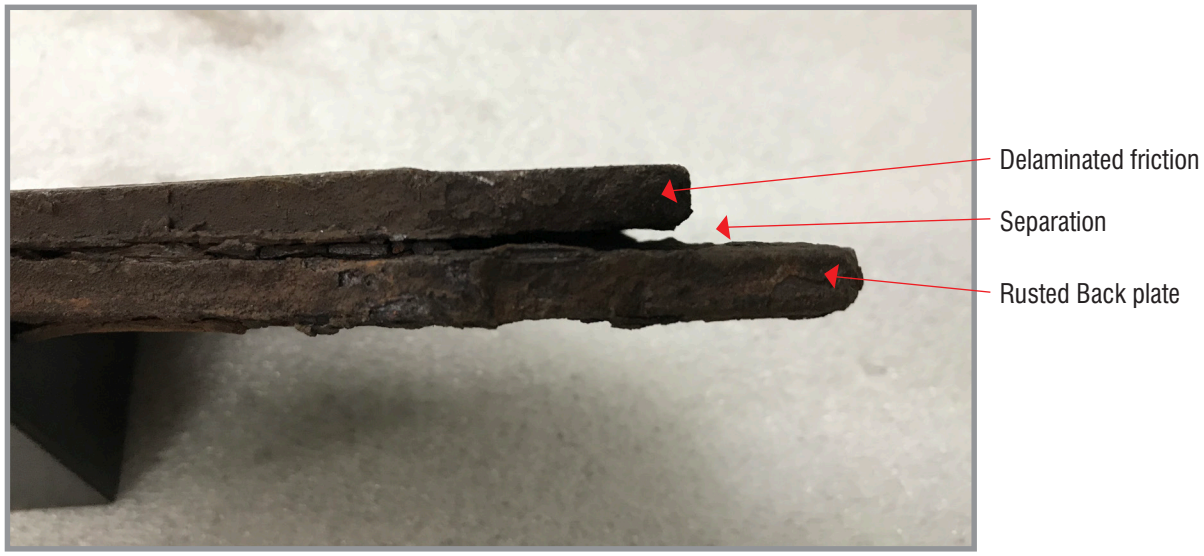

FIG. 6
PAD EDGE-LIFT

- **Noted in 11.2% of the cases (or 358 cases)**
- Partial to full-width gap at the steel back-plate, typically accompanied with corrosion / rusting
- **Consequence: Noise; vibration/roughness; drag; "Rust-jacking" of friction away from the back-plate, leading to loss of braking power and vehicle braking instability (a tangible safety risk)**

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v) Broken/Separated Friction (Fig. 7)

FIG. 7
BROKEN/SEPARATED FRICTION

- **Noted in 5.3% of the cases (or 170 cases)**
- Substantial part of friction separated from pad/ back plate.
- **Consequence: partial or full friction separation from the back-plate, leading to loss of braking power and vehicle braking instability (a tangible safety risk).**

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4. Summary

Analysis to date indicates that **a relatively high number of these failures can lead to braking instability or loss of braking;**

11.0% of the cases for excessive rust (352 out of 3200 cases)

11.2% for Pad Edge-lift / Delamination (358 out of 3200 cases)

5.3% for Broken Friction (170 out of 3200 cases)

This indicates that a substantial number of brake pads are failing; some with accumulating, difficult to detect, safety risk, well before they would need to be replaced for normal wear-out (defined as 1.5 – 2.5 mm friction remaining above the back-plate). It must be noted that the root cause of the majority of the failure modes observed is advanced corrosion from rust.

5. Conclusion

Continued **use of sub-standard product and material**, coupled with the use of "black steel" [1] - which is hot rolled steel that has not gone through the pickling and oiling process to remove impurities, rust, scale, and other contaminants - **and a lack of regulations or industry-standard practices can directly lead to the above-mentioned failure modes.**

This is cause for a major public safety concern, and ought to be a call for due consideration of industry and regulatory change.

Reference: 1. Lambert, et al., (2015) 'Effects of 'Black Steel' and its Contribution to premature Brake Pad Replacement and Brake Pad Failure' Global Brake Safety Council