Evaluating Wear on AMG Carbon-Ceramic Rotors

The Objective

I am trying to evaluate the wear on my car's carbon-ceramic rotors. In particular, since I will do a few track days each year, I need to develop an understanding of how the rotors are wearing, based upon the car's use/mileage, so I can predict and know when the rotors will require replacement. Especially when running a car on race tracks, understanding the condition of the wheels/tires and braking system is crucial, in terms of safety.

The WIS Process

The WIS documents AH42.10-P-9406-07RQ and AP42.10-P-4258-02RQ specify how the carbon-ceramic rotors are to be checked on my GTR Pro. Unfortunately, the procedure given in AP42.10-P-4258-02RQ is so problematic that, for practical purposes, it is effectively useless and thus is of significant safety concern.

The process specified in document AP42.10-P-4258-02RQ fails for the following reasons:

- the process is not rigorously specified and can lead to erroneous results
  - for taking the pictures, the process specifies "Distance approx. 10 cm, select macro function without flash." but taking pictures at that distance easily results in capturing shadows from the camera and/or operator which can affect the analysis
  - differences in digital cameras (light-sensor, resolution, iso range, lens characteristics, etc.) can yield widely differing results
  - differences in lighting can also yield results that vary significantly
  - a rigorous process would require the use of a camera meeting some minimal specifications and a jig that controlled the camera placement and the lighting
  - without proper controls, especially controlled lighting (amount, placement, diffusion, temperature), the process is very error-prone
- the process is too subjective and can lead to erroneous interpretations
  - the instructions state "Count all the squares in which burnt surfaces (light points) are visible ..." but there's no rigorous definition of what constitutes a "light point" (or even a set of good reference examples)
  - the accuracy of this process relies upon an interpretation (from the person performing the process) of what constitutes a "light point"
  - the accuracy of this process relies upon the judgement/"guesstimate" of the relative areas covered by "light points" versus "not light points"
  - the lack of a rigorous "light point" definition and rigorous way to evaluate the "light points" makes this process very error-prone, even if you have rigorously captured wear-indicator pictures
  - a non-subjective process would use a tool/app that processed rigorously captured pictures and analyzed them using digital processing techniques (such as light-threshold and relative-area computations) to arrive at accurate and consistent results
- the process does not appear to account for the deposits of disk-pad material on the rotors
  - it appears that, when disks are burnished/"bed in" the disk-pad material that's deposited on the rotor surface can significantly change the colouring within the wear-indicator circles
- the process is too time consuming
  - even though it is supposed to be part of various regular maintenance procedures, it is doubtful that most dealers will actually perform this test due to its cost/complexity

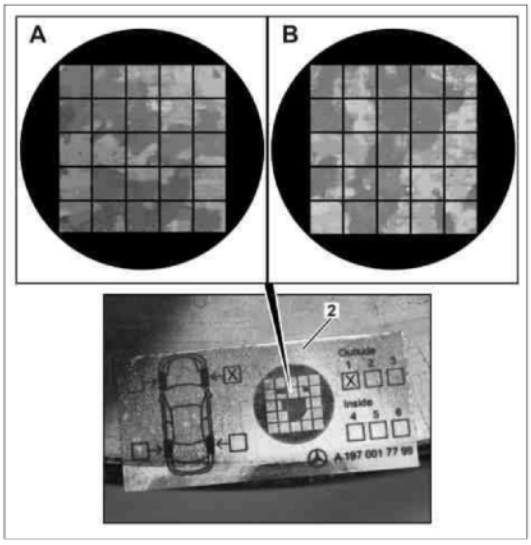
The inadequacy of this brake-safety evaluation process results in a frightening scenario for such an important safety system on a car that's marketed as having serious on-track credentials.

While other manufacturers' carbon-ceramic rotor-wear evaluation techniques also involve thickness checks and allow for weight checks, I could find no such checks in WIS (though that's not proof that they don't exist).

Initially, I attempted to use the specified masking tool (Part number: A 197 001 77 99), but quickly found issues with this approach:

- using the tool is "finicky" and greatly increases the amount of time required to take the wear-indicator pictures
- the tool has a glossy camera-facing surface which adds to the difficulty of getting a proper picture/image
- the tool has very limited stickiness so often doesn't adhere properly when being used
- the tool picked up "black stuff" debris with each application, thus increasingly altering successive measurements (indicators were first wiped with 50/50 isopropyl alcohol/water)
- the tool is rather costly at about $30 CAD per "sticker" – with the process seemingly calling for 1 sticker to be used per rotor, that's a tool cost of about $120 CAD per vehicle per check (assuming you used the check-boxes on the sticker) ... plus 1-time caliper-bolt costs

The WIS reference/example of "light points" is given by the following graphic and provides an example that's oversimplified, inadequate and leaves actual wear-indicator pictures very much open to interpretation.



It's worth noting that WIS document AP42.10-P-4258-02RQ is a subset of what's in the 2020 GTR Operator's Manual:

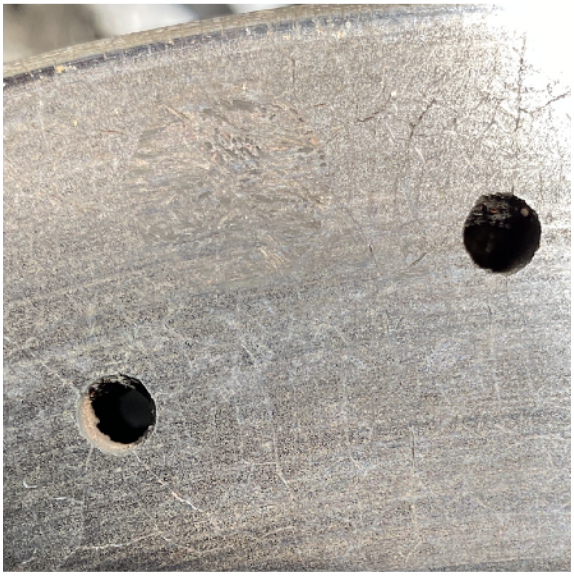
- Carbon-ceramic brake disc:
  - Visual assessment of the brake disc for mechanical damage
  - Wear measurement using the indicator field method; alternatively using the Proceq Carboteq® measuring device (e.g. in the AMG Performance Center or at AMG Trackdays)
  - Visual check
  - Crack test
  - Wear thickness test

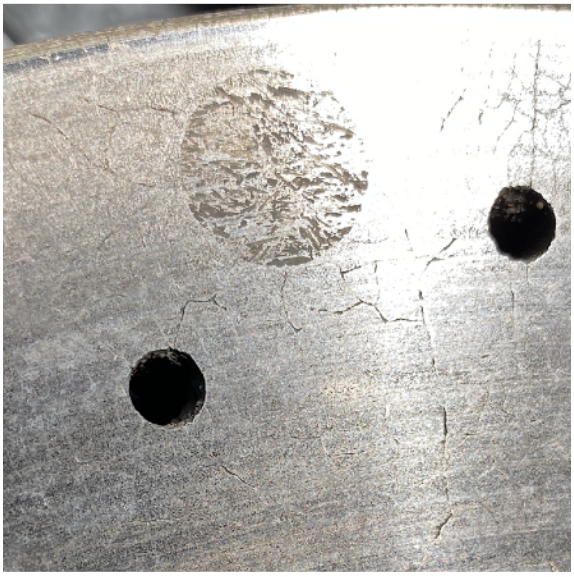
I quickly gave up on the mask-tool and created an image mask that I could apply to the digital image to achieve the equivalent measurement capability.

Why I Won't Rely Upon the WIS Process

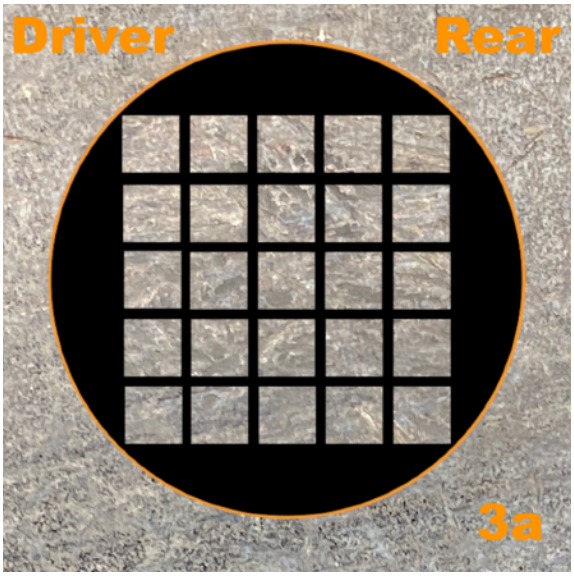
This is just one example that illustrates the variability of the results due to problems with the WIS process, as stated above. The pictures were captured using an iPhone 11 and any adjustments were applied via the Preview application (on an iMac) using adjustments to the light/colour graphs, saturation and/or colour temperature.

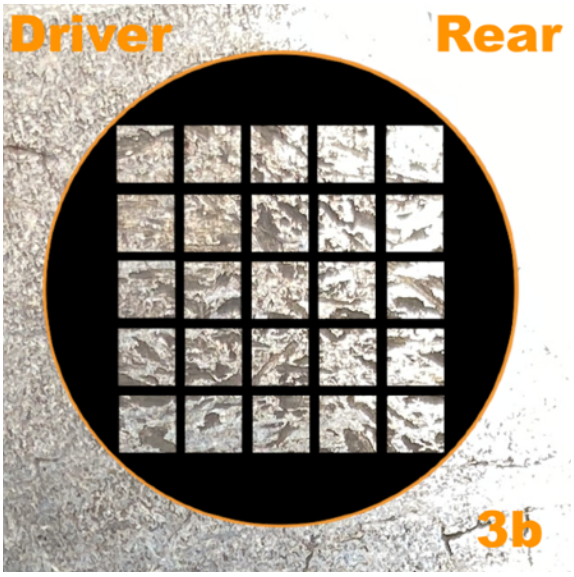
These are 2 "raw" pictures of the same rotor wear-indicator that were captured under bright-light conditions, one after another, with only a small change in shooting angle. They illustrate the type of significant differences that can result from not having a rigorous process/tool-set (i.e., filming "jig") for obtaining the pictures:





Applying a mask tool to these pictures yields the following:

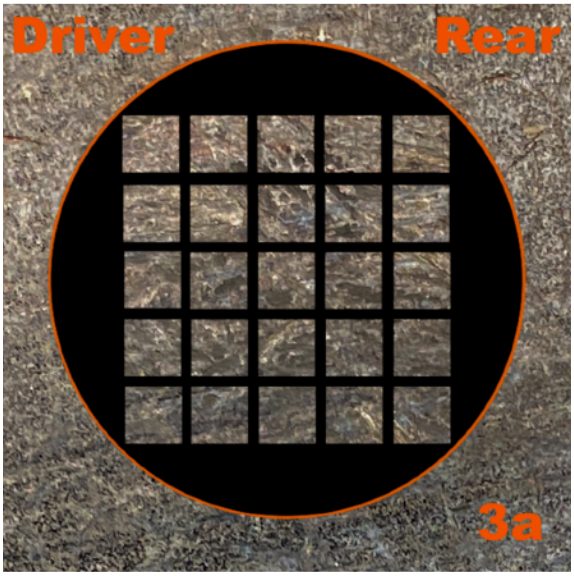


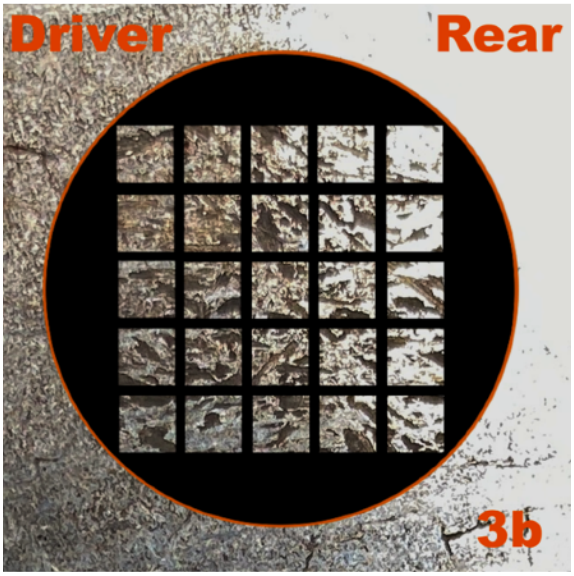


Using the above left photo would imply there are very few "light point" areas. Using the above right photo would imply a very large percentage of "light point" areas, perhaps 80-90% "light point squares." In addition to the lighting-differences issue this illustrates, I strongly suspect that

much of the "white points" appearance is due to the fact that the rotor has (proper) brake-pad deposits from the bed-in process.

Using some image processing to somewhat normalize the above pictures yields the following:





Even with all this effort to normalize these pictures, there's still a significant difference between them and the interpretation/evaluation that could result. For this process to work, you'd first need to be able to get consistent pictures.

The Current Situation

To repeat, the problem is that WIS specifies a rotor-wear measurement process that lacks rigour in tools and definitions and that will result in inconsistent pictures that lead to differing interpretations of "light points" and wear-indication counts. The WIS approach ends up being more subjective than deterministic ... which will result in actions that are either overly costly or potentially dangerous for the customer.

If used beyond their wear limits, carbon-ceramic rotors can fail suddenly and catastrophically so it's important to have an accurate rotor-wear evaluation process. Furthermore, for vehicles that see track duty, it's also important that the evaluation process be relatively easy, quick and reasonably inexpensive to allow checks at regular intervals so one can accurately predict when the rotors will need to be replaced.

Wear-prediction requires both data from on-going checks and some collective knowledge regarding how wear is expected to progress. Currently, it appears that there is neither a viable brake-rotor wear check or a collection of wear-pattern data available from Mercedes-AMG (or anywhere else I could find, locally).

Other manufacturers/suppliers have different approaches, the most common being to determine rotor-wear and replacement by using the rotor's thickness and weight. Some state that the wear indicators are used to simply indicate when it is time to remove the rotor and actually weigh it and that the wear-indicators are only visual wear indicators and not the final deciding factor.

Weighing the rotors is also very time consuming, costly and must be done with extreme care if accurate results are to be obtained. As such, determining rotor-wear by weight is not a practical method for most people who run their cars on a race track, unless they're part of a dedicated race team.

My Solution

Newer carbon-ceramic rotors on AMGs are imprinted with the information that allows an accurate wear-status to be determined using the Carboteq testing tool (https://www.youtube.com/watch?v=asnGXOmQsYU). This is also mentioned in the 2020 GTR Operator's Manual (as indicated above).

Audi has specified that, for all 2018 and later carbon-ceramic rotors, evaluation must be done only using the Carboteq testing tool. For such a fundamental safety item, the only (seemingly) definitive wear-measurement tool that's not prohibitively labor intensive is the Carboteq tool. Depending upon rim design, it's also often possible to use the Carboteq tool to measure rotor wear without removing the wheels.

I started out with the idea that I'd use the WIS strategy to check the wear on my car's carbon ceramic rotors after each track day, when I do a post-mortem wear and safety check. When I learned that the WIS-specified check is not useful and that my service centre does not have a Carboteq tool (nor has plans to obtain one), I decided that I needed to purchase my own Carboteq tool because the safety risk is too great, otherwise. The alternative of having the rotors weighed each time, would be too time-consuming for me to do and would eventually cost more than the Carboteq tool if I paid to have it done.

As such, I now own a Carboteq tool. To me, this is a safety requirement since the car is tracked.