I think the best way to explain the DR is to go block by block. If you notice each data entry block is numbered.

Block 1: DV6-R07766 This number is the official PR/DR number for this document as it will be recorded in the Shuttle Program Non-Conformance Database and is not system or sub-system specific.

Block 2: AFT-2-08-023 This is a Work Authorization Document (WAD) number that was directing technicians to install replacement tiles. It is not a PR/DR which addressed hardware problems observed during planned pre-flight inspections, or during the execution of other PR/DRs (think unplanned work). The document AFT-2-08-023 was a Test Preparation Sheet (TPS) which was used for planned removal and replacement of parts that were not discrepant. So, this DR officially documents excessive tile damage to the noted tile, and subsequent disposition (page 2) was official direction to remove the tile, identify it as scrap, and route it to Logistics for disposal.

Block 3: Self-explanatory. In this case OV-102 Columbia was in OPF High Bay 1 for pre-flight processing. The OPFs were massive hangars about 250 feet long, 150 feet wide, with a ceiling height of 95 feet. They were air-conditioned and conditions inside were a constant 72 F and 42 % RH. They are amazing hangars with fixed and movable platforms that provided access to all upper surface areas of the orbiters. When the orbiter was in the OPF it was on jacks and the lower surface was approximately 8 to 10 feet off the floor.

Block 4: This is the End Item Control Number or WAD number and was a tracking number during processing. There were many EICNs for the orbiter and there was a log book that tracked documents. This log was known as the TAIR (Test and Inspection Record) The number has much meaning: "AFT": Since the orbiter TPS was a huge system, to simplify tracking and work scheduling, the vehicle was broken down into sections. The aft section began at the aft edge of the payload bay doors and included the aft fuselage, the body flap, and the orbiter base heatshield (the bulkhead the main engines are located.) The vertical tail had it's own TAIR "VERT", as did the OMS pods, which got kind of tricky since they were interchangeable to the orbiters. "2" Means OV-102 or Columbia. "08" Means this document was initiated during preflight processing for Columbia's 8th flight. "0904" is a sequential number. This means this is the 904th PR/DR written against Columbia in her history to date. And yes, we did exceed 9999 PRs in a few instances near the end of the program. I think OV-103 Discovery did it for the FWD and AFT TAIR logs.

Block 5: This block did not apply to TPS and was eliminated from later revisions of this form.

Block 6: Self-explanatory. But, this DR was written against a "sub assembly". See Block 7 for more detail.

Block 7: Self-explanatory. But, this is sort of special in that it was written against the V070-395001-008 Part number, which is actually not a sub assembly, but is an Installation. This PN is several steps up from an individual tile. The part "tree" goes something like this. There is an individual part, a sub-assembly of parts, and assembly of parts, and then an installation. This part number actually captures all tiles in the aft area of the orbiter (V070-395XXX).

Block 8: Self-explanatory. At the individual tile level this number is shown as the OCN on page 2 of this WAD. OCN means "Order Control Number". This number is the actual document number that fabricated the tile, in this case 008213. I'll explain what this number means later.

Block 9: Self-explanatory

Block 10: Vendor. This number is actually what is known as the Cage Code. Rockwell (the original manufacturer of the orbiters) CAGE code is 03953. "RD" just indicates Rockwell Downey but that isn't a required detail.

Block 11: Next Higher Assembly. That number is the next drawing number of the "tree" described previously. This particular number is the top assembly number for OV-102 Columbia (that's what the -002 means).

Block 12: STS # EFF is STS and Effectivity. This one indicates Columbia's flight 8 was known as STS-34 when this DR was written. Due to Challenger, which happened 4 months prior to this DR initiation, the STS number was changed to 28 and 102 flew a DOD mission.

Block 13: Self-explanatory. But, this DR was written by an old friend Paul Summers. He was an older Quality Inspector at the time, and was around for STS-1. He was a wonderful guy and was great to work with always. He was indeed a gem and we all miss him. 51-11 is his department number, and 0740 was the OPF-1 TPS Quality Desk phone number. **The full number was 867-0740. Yes, 867-5309 was a real number and it belonged to the Bay 1 Aft TPS Shop. They had to change the number because of the song by Tommy Tutone.**

Block 14: Self-explanatory.

Block 15: Non-existent. Orbiter TPS used a slightly different form than all other orbiter systems and the data was normally included in this block did not apply to TPS.

Block 16: Item. This is the number of the discrepancy in this DR. PR/DRs could document more that one problem with a part.

Block 17: Problem Description. There is a lot here. The block HRSI 9/22 is checked. This means this tile is a black tile with a density of 9 lb per cubic foot. Other tiles in areas where more strength is needed were 22 lb density tiles. LRSI tiles were white and in lower temperature regions. FRSI means "Flexible Reusable Surface Insulation". This stuff was used in low temperature locations such as the payload bay doors and the upper surface of the wings. It was made of Nomex felt and was .320 inch thick, but was twice that in some locations. It was simple to install and was fairly damage tolerant. RCC is Reinforced Carbon Carbon. This was the grey TPS on the highest heat areas of the orbiter like the nose cap and the leading edge of the wings. There were several types of gap fillers. Mini Q weren't used after Challenger. A carrier panel was a panel that was attached to the orbiter with fasteners, and could be removed to provide access to other components like fittings, mechanisms, electrical connectors, etc. Carrier panels could have 1 tile on them or several.

This DR documented numerous tiles in the V070-395903 drawing, which had approximately 100 or so tiles, that were damaged. These were susceptible to "peppering" at T-0, which was a fairly violent event. While the pad was clean, debris was unavoidable. But, there is an interesting twist to this DR. You'll notice the word "densified" is in the problem description. This is where this tile gets interesting and really make it a rare example. The story is long but is well documented on the internet. Bottom line is during STS-1 launch processing, we discovered that tiles were failing a "bond verification" test. This test applied approximately 250 lbs tensile load to the tile after it was bonded to provide a general indication that the installation was good and that the RTV adhesive cured properly. What was happening was tiles were breaking just above the bondline at approximately 4 to 6 psi. NOT GOOD. Engineers figured out the fix, which was a process called densification. Densification is a process where a water-based liquid with silica and other chemicals we called Ludox was applied to the bottom of the tile, sort of squeegeed on. It had to be hand-worked into the slica fibers to fill space. The process created a densified layer of silica that could withstand the tensile loading applied during flight and the BV process. It raised the tensile strength of 9lb tiles from less than 10 to over 13. It basically saved the program. So, all tiles on the lower surface of the vehicle, approximately 15,000 give or take, had to be removed, densified and reinstalled prior to STS-1. This issue significantly affected the launch date of STS-1. At one point there were over 600 TPS technicians removing and replacing tiles. My wife was one of them.

Now, this is where your tile turns special. You see, the tile you have was one of very few that flew 7 flights on Columbia that were NOT densified. I'm not sure how many, f any undensifed tiles remained on Columbia after flight 7. I would venture to say there are no other flown undensified OV-102 tiles out there. And since all tiles manufactured after 1979 were densified, OV-102 was the only orbiter ever to fly with them.

The figure in block 17 was obviously a typical tile with provisions to sketch the location of any damage or defect. The large square is the visible side of the tile or Side 1, and the narrower rectangles were the sidewalls of the tile. The dashed lines indicate the tile teminator line, which is the edge of the RCG coating. The are below the terminator is a vent zone. We had strict requirements for the area of the vent zone on a tile. The vent zone allowed the tile to vent itself during ascent, else the RCG on side 1 or OML (outer mold line) of the tile could pop off, which would significantly reduce the life of a tile as the RCG prevents erosion of the silica as well as its thermal and emissive properties.

Cause: Self-explanatory. Could be flight, ground processing induced damage, workmanship issues, and the like.
17A Validation: Just that. The validator could be a Quality Manager or Quality Engineer. They reviewed the PR/DR form for accuracy and signed it if it met all criteria. The signer of this DR was Gary Barrett. He worked the program from start to finish. All around good guy too. I believe he is retired now and living in the New Smyrna Beach area.

Block 18: This block indicated if certifications were required to perform any disposition that would be in block 30.

Block 20: The constraints system was how we controlled when work had to be done and what major processing milestone the discrepancy held up. Constraints were a very important piece of processing a launch vehicle. For instance, most tiles on the lower surface of the orbiter were only accessible in the horizontal orientation in the OPF. Once in the VAB or at the Pad, there was no physical access to it. So, since this is a TPS discrepancy, only a TPS engineer can enter a constraint. A constraint consisted of a document number, and a step or operation that performed a task or in most cases closeout of an area of removal of access. That meant that whatever work a PR/DR did, MUST be completed before the step of the constrained document could be performed.

Therefore, applying proper constraints to a document was insanely important. You did not want to be the engineer that missed a constraint, and the vehicle rolled to the pad with an open tile cavity. Applying correct constrains was one of my pet peeves. I trained many engineers on the proper use of constraints, yet some failed to see the importance. That is until they missed one and got called to the 6th floor, where they had to deal with the Chief Engineer and the Director of Orbiter Processing. You really did not want to be invited to that room.

Block 21 Crit. This was the Criticality Code for the specific discrepant part. Crit codes were 1, 1R, 2, 2R, and 3. Tiles had a special Crit Code of 1/3. Crit Codes were based on very detailed failure analysis and considered any system redundancy. Since TPS had no redundancy it was Crit 1. The /3 part was a very complicated being that would take days to explain.

Block 29 Item: This block and block 30 could contain short dispositions or instructions to address the problem. Most dispositions would not fit there, like this DR, and a page 2 and subs could be added. Some PRs could get to be 70 pages if they got multiple flight deferrals.

Block 31. If Block 30 had worksteps, the tech, QA and even a NASA QA would apply their stamp which was essentially your signature.
Attachments: Additional discrepancies could be added to a PR and they were known as page 1A and subs. If an attachment was added, the initiator would stamp the appropriate block.

Block 33: When all work in the PR is complete, a Quality Inspector would stamp this block.
Block 23: This block indicated if weights of components installed needed to be recorded within the document. It was rarely used by TPS and was removed from later revisions of this form.
Block 24 Retest: This indicated whether the discrepancy invalidated a test already performed. For instance, if a tile damage on a nose gear door tile interfaced with the sealing surface, and nose gear hydraulic functional (V1098, sorry, the document numbers are still in my head) this block indicated that the hydraulic functional had to be reperformed. These retests could significantly affect a processing flow.

Block 25. Hazardous. Whether this PR contained hazardous operations

Block 26. MR Req. This block indicates if MRB action was required during the execution of this PR. MRB action meant say, a particular condition exceeded drawing requirements, but was determined acceptable for limited or unlimited use based on engineering analysis or evaluation. MRB is a powerful tool and a very common process in the aerospace industry. Some repairs had no flight limitations, and some did. In TPS we had many defects or repairs that were limited to a flight-to-flight basis. If so, engineers would do a detailed hands-on post-flight evaluation to look for indication of debonds, thermal degradation, etc. If there were no signs of flight degradation, we could fly the defect or repair again. These were called deferrals as I mentioned previously.

Block 36. Related Reports: This block indicated if any attachments such as photos, charts, or other Attachments were included in the completed PR.
Block 19 EO: EO is an acronym for Engineering Order. If checked yes, that meant this document processed an Engineering Order disposition. An example would be the PR documented an error in a drawing. The disposition would direct the Design Engineers to change the drawing and fix the error.

Block 34 Data Code: This block was completed by Configuration Management people after closure. This DR eventually would have "V39T" in the first 4 digits. The rest would include various letters and numbers that were used in trend analyses and Quality Engineering functions. Engineering only applied the first four digits. The rest was voodoo to us.

Block 37, 38 and 39 RC Action: Means Recurrent Control Action. If a problem repeated a few times, such as damage to certain tiles during an operation such as the installation of a non-flight piece of ground support equipment, a Recurrence Control Engineer would check this box, and would tell the system engineer to fix the issue such as redesign or a process change. The RC Engineer would apply a due date for the RC action. Completion did not usually constrain closure of the initiating PR. Fortunately TPS processed very few RC actions over the life of the program.

Block 40: Another post-closure bit of data. This block indicated if the action taken by the PR required an update to the Tile Information Processing System or TIPS. This system was very specific and was an insanely detailed database for TPS. This is the system that could tell us everything about every tile, blanket, gap filler, and thermal barrier on the vehicle. For instance, I have a small version of this system on a thumb drive. With this, I can determine the installation date, the installation document number, the OCN of the part, what density the tile is, if there are any non-design gap fillers installed adjacent to it and more. It is a graphical database as well which means I can type in a tile part number and a line image of the vehicle is displayed of the tile's location, which was very helpful during processing.

So that's the gist of the DR scan. The details of the tile you have are:
It was an original build tile, which means it flew the first 7 flights of Columbia. It was made in Sunnyvale, California by Lockheed, who manufactured approximately 85% of all shuttle tiles. It was removed from Columbia on 15 May 1986 by the document AFT-2-08-023, a TPS type of WAD as I explained earlier. which also installed the replacement tile shortly thereafter. The OCN of your tile is 008213, which is a Lockheed Sunnyvale OCN. Lockheed manufactured what we called "design tiles" which means they were made to specific dimensions in the engineering drawing V070-395903. They were CNC machined using the old punch tape programs. Again, the V070-395903-145 tile you have is quite rare IMO because it is a flown undensifed tile.

A word about tile manufacturing. There were other types of tiles called "closeout" which meant the specific dimensions of the tile were not in the drawing. The boundaries of closeout tiles were shown as being .055 inch from the adjacent tile. These tiles were manufactured very differently and the DR refers to it briefly. For closeout tiles, a foam and plaster 3d pattern was handmade after all adjacent tiles were installed. This "tracer pattern" was placed in what essentially was a 3 axis pantograph machine where a stylus was run over all sides of the tracer pattern, while a router was on the other end machining the silica block. This work took a great deal of skill and there weren't many folks who were good at it. One of the originals is a friend of mine and we speak often. He was a master on the tracer mill.

Lockheed only made design tiles to supply original orbiter builds. If a replacement tile was needed at KSC, Rockwell International (later Boeing) made them in Palmdale, CA. until about 1990. That is when KSC built our own tile manufacturing shop. After that, all replacement tiles were made at KSC, with the exception of tiles installed by Boeing during Orbiter Down Period (OMDP) modifications in Palmdale. Lockheed shut down tile manufacturing in about 1990-ish, but rumors are they were still making variations for black projects well past 1990. Palmdale officially shut down tile manufacturing for shuttle around 2002 or so as OMDPs were accomplished at KSC, which saved millions of dollars.

Despite the delicate nature of orbiter tiles, it's interesting to note that about 95% of original build tiles lasted the life of each vehicle. Endeavor led the fleet with nearly 10% of original tiles being replaced, and most of them during the orbiter hardening mods we did after the Columbia accident.

I hope this helps you in some way. I think you have a rather rare tile.

You probably figured it out early, but I have a great passion for the shuttle program. My 25 years working on it were undoubtedly and without question the best 25 years of my career. Now that I'm retired, I look back on what we accomplished and it was quite special. Growing up on the Space Coast watching every Apollo launch from our front yard, the schoolyard, or within the confines of KSC for two of them, drove me to be a part of the space program. The journey from a 9-year-old kid watching those launches and the lunar landing, to sitting in Firing Room 3 for several shuttle launches makes me shake my head in amazement. Sometimes it's hard for me to believe I got to do what I did.

Kind Regards,
Charlie Romeo OV-104 Thermal Protection System Engineering (Retired)