This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D5340 – 20

Standard Test Method for Airport Pavement Condition Index Surveys[1]

This standard is issued under the fixed designation D5340; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of airport pavement condition through visual surveys of asphalt-surfaced pavements, including porous friction courses and plain or reinforced jointed portland cement concrete pavements, using the Pavement Condition Index (PCI) method of quantifying pavement condition.

1.2 The PCI is a measurement of the collective judgement of pavement maintenance engineers. It directly relates to M&R needs and indirectly to pavement structural integrity and functional condition indicators. The PCI is not intended to replace the direct measurement of roughness, structural capacity, texture, or friction.

1.3 The PCI for airport pavements was developed by the U.S. Army Corps of Engineers through the funding provided by the U.S. Air Force (**1-3**).[2] It is further verified and adopted by FAA (**4**) and the U.S. Naval Facilities Engineering Command (**5**).

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 6.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *additional sample*—a sample unit inspected in addition to the random sample units to include nonrepresentative sample units in the determination of the pavement condition. This includes very poor or excellent samples that are not typical of the section and sample units which contain an unusual distress such as a utility cut. If a sample unit containing an unusual distress is chosen at random, it should be counted as an additional sample unit and another random sample unit should be chosen. If every sample unit is surveyed, then there are no additional sample units.

2.1.2 *asphalt concrete (AC) surface*—aggregate mixture with an asphalt cement binder. This term also refers to surfaces constructed of coal tars and natural tars for purposes of this test method.

2.1.3 *pavement branch*—a branch is an identifiable part of the pavement network that is a single entity and has a distinct function. For example, each runway, taxiway, and apron areas are separate branches.

2.1.4 *pavement condition index (PCI)*—a numerical rating of the pavement condition that ranges from 0 to 100, with 0 being the worst possible condition and 100 being the best possible condition.

2.1.5 *pavement condition rating*—a verbal description of pavement condition as a function of the PCI value. Fig. 1 shows two examples of PCI rating scales.

2.1.6 *pavement distress*—external indicators of pavement deterioration caused by loading, environmental factors, or construction deficiencies, or a combination thereof. Typical distresses are cracks, rutting, and weathering of the pavement surface. Distress types and severity levels detailed in Appendix X1 for AC and Appendix X2 for PCC pavements must be used to obtain an accurate PCI value.

2.1.7 *pavement sample unit*—a subdivision of a pavement section that has a standard size range: 20 contiguous slabs (±8 slabs if the total number of slabs in the section is not evenly divided by 20, or to accommodate specific field condition) for PCC airfield pavement and 5000 contiguous square feet (±2000 ft^2 (450 ± 180 m^2) if the pavement is not evenly divided by 5000, or to accommodate specific field condition) for AC airfield pavement and porous friction surfaces.

[1] This test method is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.42 on Pavement Management and Data Needs.

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[2] The boldface numbers in parentheses refer to a list of references at the end of the text.

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FIG. 1 Two Examples of Pavement Condition Index (PCI (Trademarked)) Rating Scales

2.1.8 *pavement section*—a contiguous pavement area having uniform construction, maintenance, usage history, and condition. A section should also have the same traffic volume and load intensity.

2.1.9 *porous friction surfaces*—open-graded select aggregate mixture with an asphalt cement binder. This is a subset of asphalt concrete-surfaced pavements.

2.1.10 *portland cement concrete (PCC) pavement*—aggregate mixture with portland cement binder including nonreinforced and reinforced jointed pavement.

2.1.11 *random sample*—a sample unit of the pavement section selected for inspection by random sampling techniques, such as a random number table or systematic random procedure.

2.1.12 *structural capacity*—quantitative determination of load-carrying capability.

2.1.13 *structural integrity*—observation of soundness (the state of being whole and undivided).

3. Summary of Test Method

3.1 The pavement is divided into branches that are divided into sections. Each section is divided into sample units. The type and severity of airport pavement distress is assessed by visual inspection of the pavement sample units. The quantity of the distress is measured as described in Appendix X1 and Appendix X2. The distress data are used to calculate the PCI for each sample unit. The PCI of the pavement section is determined based on the PCI of the inspected sample units within the section.

4. Significance and Use

4.1 The PCI is a numerical indicator that rates the surface condition of the pavement. The PCI provides a measure of the present condition of the pavement based on the distress observed on the surface of the pavement, which also indicates the structural integrity and surface operational condition (localized roughness and safety). The PCI cannot measure the structural capacity, neither does it provide direct measurement of skid resistance or roughness. It provides an objective and rational basis for determining maintenance and repair needs and priorities. Continuous monitoring of the PCI is used to establish the rate of pavement deterioration, which permits early identification of major rehabilitation needs. The PCI provides feedback on pavement performance for validation or improvement of current pavement design and maintenance procedures.

5. Apparatus

5.1 *Data Sheets,* or other field recording instruments that record at a minimum the following information: date, location, branch, section, sample unit size, slab number and size, distress types, severity levels, quantities, and names of surveyors. Example data sheets for AC and PCC pavements are shown in Appendix X5.

5.2 *Hand Odometer Wheel,* that reads to the nearest 0.1 ft (30 mm).

5.3 *Straightedge or String Line* (AC only), 10 ft (3 m).

5.4 *Scale,* 12 in. (300 mm) that reads to ⅛ in. (3 mm) or better. Additional 12-in. (300-mm) ruler or straightedge is needed to measure faulting in PCC pavements.

5.5 *Layout Plan,* for airport to be inspected.

6. Hazards

6.1 Traffic is a hazard, as inspectors must walk on the pavement to perform the condition survey. Inspection must be approved by and coordinated with the airport operational staff.

6.2 Noise from aircraft can be a hazard. Hearing protection must be available to the inspector at all times when airside inspections are being performed.

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7. Sampling and Sample Units

7.1 Identify areas of the pavement with different uses such as runways, taxiways, and aprons on the airport layout plan.

7.2 Divide each single-use area into sections based on the pavement design, construction history, traffic, and condition.

7.3 Divide the pavement sections into sample units. If the pavement slabs in PCC have joint spacings greater than 25 ft (8 m), subdivide each slab into imaginary slabs. The imaginary slabs should all be less than or equal to 25 ft (8 m) in length, and the imaginary joints dividing the slabs are assumed to be in perfect condition. This is needed because the deduct values were developed for jointed concrete slabs less than or equal to 25 ft (8 m).

7.4 Individual sample units to be inspected should be marked or identified in a manner to allow inspectors and quality control personnel to easily locate them on the pavement surface. Paint marks along the edge and sketches with locations connected to physical pavement features are acceptable. The use of nails or other potential FOD sources is not recommended. It is necessary to be able to accurately relocate the sample units to allow verification of current distress data, to examine changes in condition with time of a particular sample unit, and to enable future inspections of the same sample unit if desired.

7.5 Select the sample units to be inspected. The number of sample units to be inspected may vary from all of the sample units in the section, a number of sample units that provides a 95 % confidence level, or a lesser number.

7.5.1 All sample units in the section may be inspected to determine the average PCI of the section. This is usually precluded for routine management purposes by available manpower, funds, and time. Total sampling, however, is desirable for project analysis to help estimate maintenance and repair quantities.

7.5.2 The minimum number of sample units (n) that must be surveyed within a given section to obtain a statistically adequate estimate (95 % confidence) of the PCI of the section is calculated using the following formula and rounding n to the next highest whole number **(1)**.

$$n = \frac{Ns^2}{\left(\left(\frac{e^2}{4}\right)(N-1)+s^2\right)} \tag{1}$$

where:

e = acceptable error in estimating the section PCI. Commonly, e = ±5 PCI points,
s = standard deviation of the PCI from one sample unit to another within the section. When performing the initial inspection, the standard deviation is assumed to be ten for AC pavements and 15 for PCC pavements. This assumption should be checked as described below after PCI values are determined. For subsequent inspections the standard deviation from the preceding inspection should be used to determine n, and
N = total number of sample units in the section.

7.5.2.1 If obtaining the 95 % confidence level is critical, the adequacy of the number of sample units surveyed must be confirmed. The number of sample units was estimated based on an assumed standard deviation. Calculate the actual standard deviation(s) as follows **(1)**:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(PCI_i - PCI_f)^2}{(n-1)}} \tag{2}$$

where:

PCI_i = PCI of surveyed sample unit i,
PCI_f = mean PCI of surveyed sample units, and
n = total number of sample units surveyed.

7.5.2.2 Calculate the revised minimum number of sample units (Eq 1) to be surveyed using the calculated standard deviation (Eq 2). If the revised number of sample units to be surveyed is greater than the number of sample units already surveyed, select and survey additional random sample units. These sample units should be evenly spaced across the section. Repeat the process of checking the revised number of sample units and surveying additional random sample units until the total number of sample units surveyed equals or exceeds the minimum required sample units (n) in Eq 1, using the actual total sample standard deviation).

7.5.3 A lesser sampling rate than the above mentioned 95 % confidence level can be used based on the condition survey objective. As an example, one agency uses the following table for selecting the number of sample units to be inspected for other than project analysis:

Given	Survey
1 to 5 sample units	1 sample unit
6 to 10 sample units	2 sample units
11 to 15 sample units	3 sample units
16 to 40 sample units	4 sample units
over 40 sample units	10 %

7.6 Once the number of sample units to be inspected has been determined, compute the spacing interval of the units using systematic random sampling. Samples are equally spaced throughout the section with the first sample selected at random. The spacing interval (i) of the units to be sampled is calculated by the following formula rounded to the next lowest whole number:

$$i = \frac{N}{n} \tag{3}$$

where:

N = total number of sample units in the section, and
n = number of sample units to be inspected.

The first sample unit to be inspected is selected at random from sample units 1 through i. The sample units within a section that are successive increments of the interval i after the first randomly selected unit are also inspected.

7.7 Additional sample units are only to be inspected when nonrepresentative distresses are observed as defined in 2.1.1. These sample units are selected by the user.

8. Inspection Procedure

8.1 The definitions and guidelines for quantifying distresses for PCI determination are given in Appendix X1 for AC pavements. Other related references **(1-8)** are also available that discuss distress survey; however, when the material in

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these references conflicts with the definitions included in this test method, the definitions in this test method are used.

8.2 *AC Surfaced Pavement, Including Porous Friction Surfaces*—Individually inspect each sample unit chosen. Sketch the sample unit, including orientation. Record the branch and section number, and number and type of the sample unit (random or additional). Record the sample unit size measured with the hand odometer. Conduct the distress inspection by walking over the sample unit being surveyed, measuring the quantity of each severity level of every distress type present, and recording the data. Distresses must correspond in types and severities to those described in Appendix X1. The method of measurement is included with each distress description. Measurements should be made to ±0.1 ft (30 mm) with the hand odometer. Summarize each distress type and severity level in either square feet or linear feet (square meters or linear meters), depending on the type of distress. Repeat this procedure for each sample unit to be inspected. A blank "Flexible Pavement Condition Survey Data Sheet for Sample Unit" is included in Appendix X5.

8.3 *PCC Pavements*—Individually inspect each sample unit chosen. Sketch the sample unit showing the location of the slabs. Record the sample unit size, branch and section number, number and type of the sample unit (random or additional), the number of slabs in the sample unit, and the slab size measured with the hand odometer. Perform the inspection by walking over each slab of the sample unit being surveyed and recording all distresses existing in the slab along with their severity level. The distress types and severities must correspond with those described in Appendix X2. Summarize the distress types, their severity levels, and the number of slabs in the sample unit containing each type and severity level. Repeat this procedure for each sample unit to be inspected. A blank "Jointed Rigid Pavement Condition Survey Data Sheet for Sample Unit" is included in Appendix X5.

9. Calculation of PCI for AC Pavement, Including Porous Friction Surfaces

9.1 Add up the total quantity of each distress type at each severity level, and record them in the "Total Severities"

AIRFIELD ASPHALT PAVEMENT CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

SKETCH:

BRANCH _____ **SECTION** _____ **SAMPLE UNIT** _____
SURVEYED BY _____ **DATE** _____ **SAMPLE AREA** *5000 S.F.*

1. Alligator Cracking	5. Depression	9. Oil Spillage	13. Rutting
2. Bleeding	6. Jet Blast	10. Patching	14. Shoving from PCC
3. Block Cracking	7. Jt. Reflection (PCC)	11. Polished Aggregate	15. Slippage Cracking
4. Corrugation	8. Long. & Trans. Cracking	12. Raveling/Weathering	16. Swell

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE
8 L	*10*	*20*	*15*							*45*	*0.90*	*4.8*
8 M	*9*									*9*	*0.18*	*4.9*
1 L	*50*									*50*	*1.00*	*21.0*
13 L	*200*	*175*								*375*	*7.50*	*27.0*
13 M	*25*									*25*	*0.50*	*20.0*
5 L	*15*									*15*	*0.30*	*2.0*
5 M	*20*									*20*	*0.40*	***9.0***
10 L	***50***									***50***	***1.00***	***4.0***

FIG. 2 Example of a Flexible Pavement Condition Survey Data Sheet

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section. For example, Fig. 2 shows four entries for the Distress Type 8, "Longitudinal and Transverse Cracking:" 9M, 10L, 20L, and 15L. The distress at each severity level is summed and entered in the "Total Severity" section as 45 ft (14 m) of low severity, and 9 ft (3 m) of medium severity "Longitudinal and Transverse Cracking." The units for the quantities may be either in square feet (square meters), linear feet (meters), or number of occurrences, depending on the distress type.

9.2 Divide the total quantity of each distress type at each severity level from 9.1 by the total area of the sample unit and multiply by 100 to obtain the percent density of each distress type and severity.

9.3 Determine the deduct value (DV) for each distress type and severity level combination from the distress deduct value curves in Appendix X3.

9.4 Determine the maximum corrected deduct value (CDV):

9.4.1 If none or only one individual DV is greater than five, the total value is used in place of the maximum CDV in determining PCI; otherwise, maximum CDV must be determined using the procedure described in this section. The procedure for determining maximum CDV from individual DVs is identical for both AC and PCC pavement types.

9.5 *PCI Calculation:*

9.5.1 If none or only one individual DV is greater than five, use the total DV in place of the maximum CDV in determining PCI; otherwise use the following procedure to determine max CDV:

9.5.1.1 Determine m, the maximum allowable number of distresses, as follows:

$$m = 1 + (9/95)\,(100 - HDV) \le 10 \quad (4)$$

$$m = 1 + (9/95)\,(100 - 27) = 7.92 \quad (5)$$

$$\text{HDV} = \text{highest individual DV} \quad (6)$$

9.5.1.2 Enter m largest DVs on Line 1 of the following table, including the fraction obtained by multiplying the last DV by the fractional portion of m. If less than m DVs are available, enter all of the DVs.

9.5.1.3 Sum the DVs and enter it under "Total." Count the number of DVs greater than 5.0 and enter it under "q."

9.5.1.4 Look up the appropriate correction curve (AC or PCC) with "Total" and "q" to determine CDV.

9.5.1.5 Copy DVs on current line to the next line, changing the smallest DV greater than five to five. Repeat 9.5.1.3 and 9.5.1.4 until "q" = 1.

9.5.1.6 Maximum CDV is the largest value in the "CDV" column.

9.5.2 List the individual DVs in descending order. For example in Fig. 2 this will be: 27.0, 21.0, 20.0, 9.0, 4.9, 4.8, 4.0, and 2.0.

9.5.3 Determine the allowable number of deducts, m, from Fig. 3, or using the following formulas:

$$m = 1 + (9/95)\,(100 - HDV) \quad (7)$$

where:

m = allowable number of deducts including fractions (must be less than or equal to ten), and
HDV = highest individual DV.

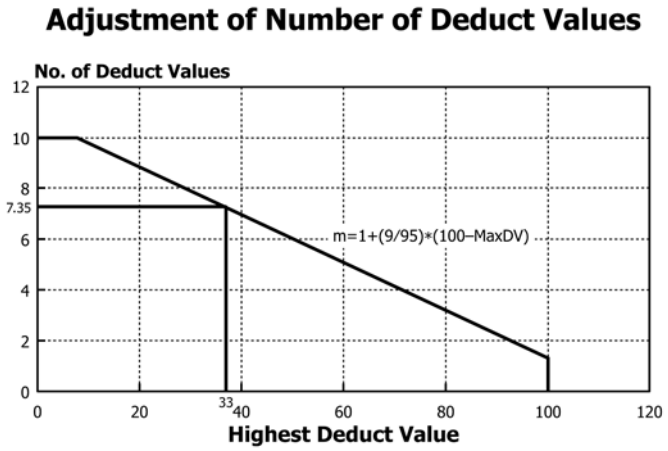

FIG. 3 Adjustment of Number of DVs

For the example in Fig. 2:

$$m = 1 + (9/95)\,(100 - 27.0) = 7.92 \quad (8)$$

9.5.4 The number of individual DVs is reduced to the m largest DVs, including the fractional part. For example, for the values in Fig. 2, the values are: 27.0, 21.0, 20.0, 9.0, 4.9, 4.8, 4.0, and 1.8 (the 1.8 was obtained by multiplying 2.0 by (7.92 – 7 = 0.92)). If less than m DVs are available, all of the DVs are used.

9.5.5 Determine maximum CDV iteratively as follows: (see Fig. 4):

#	Deduct Values										Total	q	CDV
1	27.0	21.0	20.0	9.0	4.9	4.8	4.0	1.8			92.5	4	50.0
2	27.0	21.0	20.0	5.0	4.9	4.8	4.0	1.8			38.5	3	56.0
3	27.0	21.0	5.0	5.0	4.9	4.8	4.0	1.8			73.5	2	51.0
4	27.0	5.0	5.0	5.0	4.9	4.8	4.0	1.8			57.5	1	57.5
5													
6													
7													
8													
9													
10													

Max CDV = 57.5

PCI = 100 – Max CDV = 42.5

RATING = FAIR

NOTE 1—Fig. 2 contains both low and high-severity depression, long/trans cracking, and rutting distresses. Using the algorithm in 9.6.2 it was verified that no correction is needed for any of the distress types.

FIG. 4 Calculation of Corrected PCI Value – Flexible Pavement

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9.5.5.1 Determine the total DV by summing individual DVs. The total DV is obtained by adding the individual DVs in 9.5.4, that is 92.5.

9.5.5.2 Determine *q; q* is the number of deducts with a value greater than 5.0. For the example in Fig. 2, $q = 4$.

9.5.5.3 Determine the CDV from *q* and total DV determined in 9.5.5.1 and 9.5.5.2 by looking up the appropriate correction curve for AC pavements in Fig. X3.20 in Appendix X3.

9.5.5.4 Reduce the smallest individual DV greater than 5.0 to 5.0 and repeat 9.5.5.1 – 9.5.5.4 until $q = 1$.

9.5.5.5 Maximum CDV is the largest of the CDVs determined in 9.5.5.1 – 9.5.5.4.

9.6 *Calculating the PCI:*

9.6.1 Calculate the PCI by subtracting the maximum CDV from 100: PCI = 100-max CDV.

9.6.2 PCI correction if there is a distress with multiple severities.

9.6.2.1 *Two-Severity Case*—When there are two severities of one distress in the same sample unit, the calculations need to be computed as seen below.

x_1 = distress percent of lower severity.
x_2 = distress percent of higher severity.
$X_2 = x_1 + x_2$.

The value of PCI (x_1, x_2) should be higher when compared with PCI (0, X_2) since PCI (0, X_2) has more distress percentage of higher severity. So if this not the case, the PCI of the sample unit will be computed based on X_2 and not x_1 and x_2.

9.6.2.2 *Three-Severity Case*—When there are three severities of one distress in the same sample unit, the calculations need to be computed as seen below.

l or *L* = percent density of low-severity distress percent.

m or *M* = percent density of medium-severity distress percent.

h or *H* = percent density of high-severity distress percent.

PCI (l, m, h) = PCI of the section with distress quantities of *l, m, h*.

	Distresses	PCI Value
Start with:	*l, m, h*	→ PCI (*l, m, h*)
Set *(l + m) = M*	→*0, M, h*	→ PCI (*0, M, h*)
Set *(m + h) = H*	→*l, 0, H*	→ PCI (*l, 0, H*)
Set *(l + h) = H*	→ *0, m, H*	→ PCI (*0, m, H*)
Set *(l + m + h) = H*	→ *0, 0, H*	→ PCI (*0, 0, H*)

The value of PCI (*l, m, h*) should be higher when compared with PCI (*0, M, h*), PCI (*l, 0, H*), PCI (*m, H*), or PCI (*H*). So the correct or new PCI of the sample unit should be based on the combination that provides the highest PCI.

9.7 Fig. 4 shows a summary of PCI calculation for the example AC pavement data in Fig. 2. A blank PCI calculation form is included in Appendix X5.

10. Calculation of PCI for PCC Pavement

10.1 For each unique combination of distress type and severity level, add up the total number of slabs in which they occur. For example in Fig. 5, there are two slabs containing low-severity corner break.

AIRFIELD CONCRETE PAVEMENTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH _____ SECTION _____ SAMPLE UNIT _____
SURVEYED BY LMB DATE 18 JAN 92 SAMPLE AREA 12.5' × 2.5'

Distress Types

1. Blow up
2. Corner Break
3. Long/Trans/ Diagonal Crack
4. Durability Crack
5. Joint Seal Damage
6. Patching, 5 sf
7. Patching/Utility Cut
8. Popouts
9. Pumping
10. Scaling/Map Crack/ Crazing
11. Settlement/Fault
12. Shattered Slab
13. Shrinkage Crack
14. Spalling-Joints
15. Spalling-Corner

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE
5	H	20	100	12.0
2	L	2	10	8.0
2	M	1	5	9.0
3	L	3	15	11.0
3	M	5	25	32.0
15	L	3	15	6.0
14	L	2	10	3.0
12	L	1	5	10.0

SKETCH:

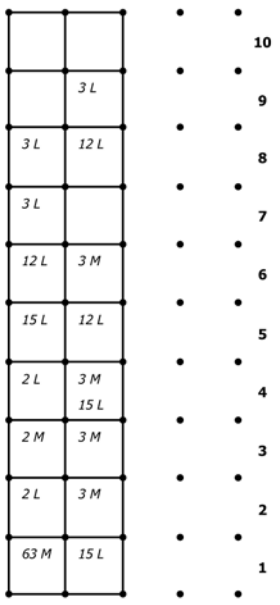

FIG. 5 Example of a Jointed Rigid Pavement Condition Survey Data Sheet

10.2 Divide the number of slabs from 10.1 by the total number of slabs in the sample unit and multiply by 100 to obtain the percent density of each distress type and severity combination.

10.3 *PCI Calculation:*

10.3.1 If none or only one individual DV is greater than five, use the total DV in place of the maximum CDV in determining PCI; otherwise use the following procedure to determine max CDV:

10.3.1.1 Determine *m*, the maximum allowable number of distresses, as follows:

$$m = 1 + (9/95)\,(100 - HDV) \leq 10 \quad (9)$$

$$m = 1 + (9/95)\,(100 - 32.0) = 7.44 \quad (10)$$

$$\text{HDV} = \text{highest individual DV} \quad (11)$$

10.3.1.2 Enter *m* largest DVs on Line 1 of the following table, including the fraction obtained by multiplying the last DV by the fractional portion of *m*. If less than *m* DVs are available, enter all of the DVs.

10.3.1.3 Sum the DVs and enter it under "Total." Count the number of DVs greater than 5.0 and enter it under "*q*."

10.3.1.4 Look up the appropriate correction curve (AC or PCC) with "Total" and "q" to determine CDV.

10.3.1.5 Copy DVs on current line to the next line, changing the smallest DV greater than five to five. Repeat 10.3.1.3 and 10.3.1.4 until "*q*" = 1.

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