Runway Pavement Loading

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Flight Operations
August 2006
The runway is long enough, but is it strong enough?
Careful trip planning should always include determining the weight bearing strength of airport pavements.
Where can you find information on pavement bearing strength?
There are many different methods of reporting runway pavement strength.

- 08/26 5577’ PAVED S/L 13, T/L 22
- 09/27 2953’ PAVED SIWL 11
- 17/35 6234’ MACADAM PCN 20/F/C/W/T
- 07/25 2362’ PAVED AUW-19
The three most common methods of expressing airport pavement strength:

- ICAO ACN/PCN system
- British LCN/LCG system
- Weight limits expressed in lbs per wheel, limits to aircraft gross weight for each mlg type, or limits to gross weight
Since 1981, ICAO has used the PCN / ACN system to designate the load bearing capability of airport pavement.

- **PCN**
  - A number which expresses the relative loadcarrying capacity of a pavement in terms of a standard single wheel load.

- **ACN**
  - A number which expresses the relative structural effect of an aircraft on different pavement types for specified standard subgrade strengths in terms of a standard single wheel load.
The PCN for a given runway is listed in the information for the airport in the Jeppesen Airport Directory:

<table>
<thead>
<tr>
<th>AIRPORT DIRECTORY</th>
<th>16 JUN 08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nancy (Illsey) Apt of Entry</td>
<td>77T</td>
</tr>
<tr>
<td>Apt Operator 033215890, Fax 033210682, Apt Manager 033292369, AFIS 033215429, Aeroclub 033217585, 0321 4903 MACADAM, SL 18, HRML, HLAL, RWY 03 (MACADAM) Right-Hand Circuit, Pilot Controlled Lighting, Ground Control can be operated by remote control, 0321 1800 GRASS, Grass runway PPR, Unspecified Custom C/R for 24hr svc, F-3, Jet-A-1, Fire 2.</td>
<td></td>
</tr>
<tr>
<td>Nancy (Ochey AB)</td>
<td>1106</td>
</tr>
<tr>
<td>Apt Administration 033662804, 033627227, Fax 03362646, F-3,</td>
<td></td>
</tr>
<tr>
<td>0321 0000,</td>
<td></td>
</tr>
<tr>
<td>HRML,</td>
<td></td>
</tr>
<tr>
<td>C/R PPR,</td>
<td></td>
</tr>
<tr>
<td>0321 4903 MACADAM, SL 11, RWY 06 (MACADAM) Right-Hand Circuit, 0321 1800 GRASS, RWY 06 (GRASS) Right-Hand Circuit, C/R, F-3, Fire 1, Nantes (La Loche)</td>
<td>42°3</td>
</tr>
<tr>
<td>Apt Administration 0146430105, Fax 0146407105, Aeroclub 014643003, 0146408370, <a href="mailto:acclaviersmoresque@airfrance.com">acclaviersmoresque@airfrance.com</a></td>
<td></td>
</tr>
<tr>
<td>0324 7133 MACADAM, SL 11, RWY 06 (MACADAM) Right-Hand Circuit, 0324 3367 GRASS, RWY 06 (GRASS) Right-Hand Circuit, C/R, F-3, Fire 1, Nantes/Atlantique Apt of Entry</td>
<td>90</td>
</tr>
<tr>
<td>Orly</td>
<td>302</td>
</tr>
<tr>
<td>Apt Administration 0303969963, Fax 030396960, AERL 2025 PAVED, SL 6, LDA 32 2567, RWY 32R Right-Hand Circuit, 14/32L 5117 UNPAVED, LDA 26 2654, RWY 14R Right-Hand Circuit, 14/32L, Fire 1, Orly see Nancy</td>
<td></td>
</tr>
</tbody>
</table>

03/21 9514' MACADAM. PCN 49/F/C/W/T
ICAO Standard System

- How do I interpret the information?
  - In this example for Nantes, France, runway 3/21 is 9514’ long, the surface is MACADAM, and:

\[
\begin{align*}
\text{PCN} & = 49 \\
F & = \text{Flexible Pavement} \\
C & = \text{Low Subgrade Strength} \\
W & = \text{High Tire Pressure Category – No Pressure Limit} \\
T & = \text{Data Based on Technical Evaluation of Pavement}
\end{align*}
\]
Consult the ACN Charts in the QRH or Performance Handbook

Gulfstream G550 Performance Handbook

Aircraft Classification Number (ACN) Charts, ctd… GV-GER-1212
Find the Correct Chart for Given Conditions

Aircraft Classification Number (ACN) Charts, etc...
Gulfstream®
Determine ACN for Operating Weight

• In this instance:
  – For a flexible runway with low strength subgrade materials – category c (or California bearing rating 6), using the maximum tire pressure of 198 psi, and maximum gross weight (90,900 lbs) the aircraft condition (ACN) number is 28.
  – 28 is less than the pavement condition number (PCN) of 49 for runway 3/21 at Nantes, France, so this runway would be usable up to max gross weight.
QRH or Performance Handbook Contains
Charts for:

- Flexible pavement with aircraft wheel inflation at maximum
- Flexible pavement with aircraft wheel inflation varying with gross weight
- Rigid pavement with aircraft wheel inflation at maximum
- Rigid pavement with aircraft wheel inflation varying with gross weight
Some airports use a British pavement rating system for runway strength reporting referred to as either 1) Load Classification Group (LCG) followed by a roman numeral (from I to VII), or 2) Load Classification Number (LCN) which is based on the Load Classification Group (LCG) system.

Airports reporting their runway strength in the LCG system are primarily found in the following countries: Mongolia, Myanmar (Burma), Nigeria, South Africa, Turkey, United Kingdom, and Zimbabwe.

The British LCG/LCN rating system is based on the original LCN system which was developed by ICAO in 1965, but makes no distinction between asphalt (flexible) and concrete (rigid) pavement. Since these two surfaces react to loads differently, LCG type LCNs are not considered to be a highly precise measure of pavement strength particularly for flexible pavements. Note: the US Military use of LCNs for documents such as the Automated Airfield Information File (AAFIF) is also based on the LCG system. (source – Boeing.com)
Jeppesen U.K. Airports Section has Airports Using Both Systems

05/23 4829’ ASPHALT. PCN 6/R/B/Y/T

08/26 7946’ ASPHALT. LCG IV
To use the LCN/LCG system, first determine the equivalent single wheel load (ESWL) using information in the QRH / Performance Handbook.

**Gulfstream G500 Performance Handbook**

**Equivalent Single Wheel Loading (ESWL)**

1. **Introduction:**

   One consideration in operating Gulfstream aircraft is the strength of runway and taxiway pavements in relation to aircraft operating weight. This can limit operational weights in some airports. One common method of evaluating an aircraft for a given runway is the Equivalent Single Wheel Loading (ESWL). ESWL accounts for the extra tire flotation for multi-wheel landing gear struts such as the dual wheel struts used on the Gulfstream aircraft. This section provides information on how to compute ESWL for the G550 and G500 airplanes.

2. **G550 and G500 Main Landing Gear Parameters:**

<table>
<thead>
<tr>
<th>Max Ramp Weight (pounds)</th>
<th>MLG Tire Size (inches)</th>
<th>Tire Spacing (inches)</th>
<th>Max Tire Pressure (psi)</th>
<th>Reduction Factor</th>
<th>Maximum ESWL (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>91,400</td>
<td>35 x 11.0</td>
<td>18.5</td>
<td>198</td>
<td>1.25</td>
<td>32,904</td>
</tr>
</tbody>
</table>

   The reduction factor in the table above assumes a rigid pavement with a radius of equivalent stiffness of 40 inches, roughly equivalent to a 13.5 inch thick concrete slab. Thinner pavements would give higher reduction factors, so the factors presented are conservative.

3. **ESWL Computation for Lower Operating Weights:**

   ESWL can be computed for lower operating weights as follows:

   \[ ESWL = \frac{(Gross \ Weight) \times (0.9) \times (0.5)}{(Reduction \ Factor)} \]
Use the ESWL to enter the chart in the Jeppesen Airport Directory introductory information.

Draw a line from the aircraft ESWL to the tire pressure. The line will intersect the LCN/LCG scale at the aircraft LCN and within a LCG range.

The aircraft LCN should be equal to or less than runway LCG limit.
Runway Weight Limits Per Wheel

07/25 5774’ MACADM S/L 22, T/L 33, TT/L 60
Runway Weight Limits Per Wheel

- In this example for NIORT, FRANCE, the weight limits for runway 07/25 are expressed in thousands of pounds for each main gear for different wheel configurations:
  - S/L 22 = 22,000 lbs for a single wheel per leg (MLG)
  - T/L 33 = 33,000 lbs for a twin or tandem wheel leg (MLG)
  - TT/L 60 = 60,000 lbs for a twin tandem wheel leg (MLG)
- Since all published pavement load limits presume that the MLG supports 95% of the aircraft gross weight, and Gulfstream aircraft MLG support 91% of the aircraft weight, the maximum aircraft gross weights in the above example would be:
  - S/L 22 = 44,000 lbs + 4% or 1,760 lbs = 45,760 lbs
  - T/L 33 = 66,000 lbs + 4% or 2,640 lbs = 68,640 lbs
  - TT/L 60 = 120,000 lbs + 4% or 4,800 lbs = 124,800 lbs
The FAA airport / facility directories use a similar runway weight limit format but with a significant difference:

**RWY 05-23 H6201X150 (ASPH-GRVD) S-75, D-158, DT-280**
Runway Weight Limits Per Wheel

- The limits in the FAA DIRECTORY for each MLG gear type are TOTAL GROSS WEIGHT, not per gear strut as they are in the previous Jeppesen publication example for Niort, France.

- In this FAA DIRECTORY example for Shreveport, Louisiana (SHV) the limits are:
  - S-75 or 75,000 lbs max weight for single wheel MLG
  - D-190 or 190,000 lbs max weight for dual wheel MLG
  - DT-280 or 280,000 lbs max weight for dual tandem wheel MLG
Other Runway Pavement Loading Formats

- **AUW**
  - All Up Weight in 1,000 lbs (maximum weight bearing capacity for any aircraft irrespective of landing gear configuration)

- **LCN**
  - Load Classification Number (instead of a Load Classification Group)

- **SIWL**
  - Single Isolated Wheel Load (equivalent to ESWL)
If Weight Exceeds Limits – What To Do

• First: Read the fine print in the introduction
  – FAA AIRPORT DIRECTORY: “Runway strength data shown in this publication is derived from available information and is a realistic estimate of capability at an average level of activity. It is not intended as a maximum allowable weight or as an operating limitation. Many airport pavements are capable of supporting limited operations with gross weights in excess of published figures. Permissible operating weight, insofar as runway strengths are concerned, are a matter of agreement between the owner and user.”
  – JEPPSESEN: “Normally the LCN/LCG of an aircraft should not be above that of the runway on which a landing is contemplated. Pre-arranged exceptions may be allowed by airport authorities.” and “The appropriate authority may establish criteria to regulate the use of a pavement by aircraft with an ACN higher than the PCN reported for that pavement.”

IN OTHER WORDS – CONTACT THE AIRPORT AUTHORITY
Pavement load limits are designed to ensure pavement lasts for designed life (20 years).

<table>
<thead>
<tr>
<th>Ratio of Aircraft ACN to Pavement LCN</th>
<th>Aircraft Passes</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1.1</td>
<td>Unlimited</td>
<td></td>
</tr>
<tr>
<td>From 1.10 to 1.25</td>
<td>3000</td>
<td>Entails acceptance of some minor failures</td>
</tr>
<tr>
<td>From 1.25 to 1.50</td>
<td>300</td>
<td>Some cracking may occur in concrete and possibly local failure in flexible surfaces</td>
</tr>
<tr>
<td>From 1.5 to 2.0</td>
<td>Very Limited</td>
<td>Permission given only after examination of pavement and test data</td>
</tr>
</tbody>
</table>
What else can be done if weight exceeds limits?

- Gulfstream aircraft have a built in margin of 4%. Most published limits presume the MLG carries 95% of aircraft weight. Gulfstream MLGS support 91% of aircraft weight. (Remember that the FAA airport / facilities directory weights are total gross weight.)
- Manage fuel loads into / out of low strength runways.
- Reduce tire inflation pressure to the minimum for aircraft gross weight – this reduces the ACN number.
If Weight Exceeds Limits – What Else To Do

MAIN TIRE INFLATION PRESSURE SCHEDULE
TIRE P/N 1158955-5 SIZE 35X11 0-16 20PR, RATED SINGLE TIRE
LOAD 23,400 LBS μ 224 PSI, CONTACT AREA 109 SQ. IN.

Pressure (PSI) (Aircraft on Ground)

Takeoff Gross Weight x 1000 LBS

Max: MUM Tire Pressure
Min: MUM Tire Pressure
CAUTION!
Ramp areas may not have the same strength as runways!
Read the fine print on the airport diagram in Jeppesen approach plates.

- No 180° turns on asphalt for aircraft over 12,500 lbs GWT.
- Twy B2 is limited to 12,500 lbs.
QUESTIONS?